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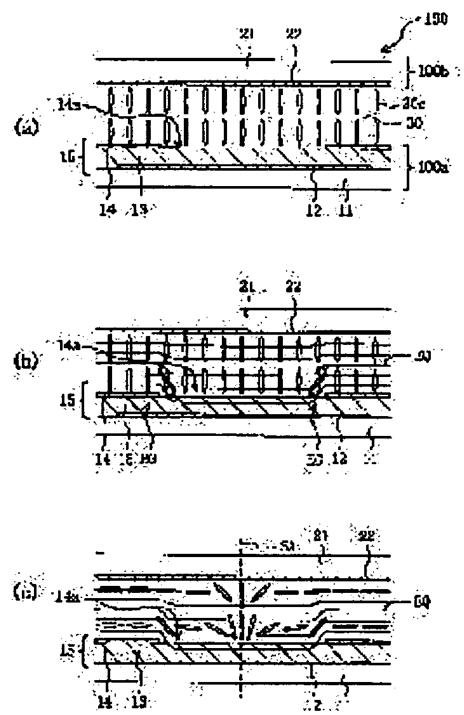
(54) LIQUID CRYSTAL DISPLAY DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a liquid crystal display device with high display quality.

SOLUTION: The liquid crystal display device carries out a display by applying voltage to a liquid crystal layer, which is in a vertical alignment condition with no voltage application, with a first electrode and a second electrode. The first electrode has a lower conductive layer, a dielectric layer covering at least a part of the lower conductive layer 12 and an upper conductive layer 14 arranged on the liquid crystal layer side of the dielectric layer. The upper conductive layer has a first opening part. Furthermore, the lower conductive layer is arranged opposite to at least a part of the first opening part via the dielectric layer.



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CLAIMS

[Claim(s)]

[Claim 1] The 1st electrode which has the liquid crystal layer prepared between the 1st substrate, the 2nd substrate, and the 1st substrate of the above and the 2nd substrate of the above, and was prepared in the aforementioned liquid crystal layer side of the 1st substrate of the above, By the 2nd electrode which is prepared in the 2nd substrate of the above and counters the 1st electrode of the above through the aforementioned liquid crystal layer It has two or more picture element fields where each is specified. each liquid crystal layer in two or more aforementioned picture element fields An orientation state is changed according to the voltage which took the perpendicular orientation state when voltage was not impressed between the 1st electrode of the above, and the 2nd electrode of the above, and was impressed between the 1st electrode of the above, and the 2nd electrode of the above. the 1st electrode of the above A lower layer conductive layer, Prepare a part of aforementioned lower layer conductive layer [at least] in the aforementioned wrap dielectric-layer and liquid crystal layer side of the aforementioned dielectric layer, and it has the **** upper conductive layer. the aforementioned upper conductive layer -- 1st at least one opening -- having -- and the aforementioned lower layer conductive layer -- the aforementioned dielectric layer -- minding -- the above -- the liquid crystal display formed so that it may counter with a part of 1st one opening [at least], even if few

[Claim 2] the aforementioned lower layer conductive layer -- the aforementioned dielectric layer -- minding -- the above -- the liquid crystal display according to claim 1 formed in the field including the field which counters the 1st one opening even if few

[Claim 3] the above -- the liquid crystal display according to claim 1 or 2 whose 1st one opening is a square even if few

[Claim 4] the above -- even if few -- a liquid crystal display according to claim 1 or 2 with the 1st one circular opening

[Claim 5] the above which the aforementioned upper conductive layer has -- a liquid crystal display given in either of the claims 1-4 whose 1st one opening is two or more 1st openings even if few

[Claim 6] Two or more 1st openings of the above which the aforementioned upper conductive layer has are liquid crystal displays according to claim 5 arranged regularly.

[Claim 7] the aforementioned dielectric layer -- the above -- a liquid crystal display given in either of the claims 1-6 which have a crevice or a hole in the 1st one opening even if few

[Claim 8] The aforementioned lower layer conductive layer is a liquid crystal display given in either of the claims 1-7 which has the 2nd opening in the field which counters the 1st opening of the above.

[Claim 9] It is a liquid crystal display given in either of the claims 1-8 whose another side either the aforementioned upper conductive layer or the aforementioned lower layer conductive layers are transparent conductive layers, and is a reflective conductive layer.

[Claim 10] the above which the aforementioned upper conductive layer has -- a liquid crystal display given in either of the claims 1-9 which forms two or more liquid-crystal domains where the 1st one opening is two or more 1st openings even if few, and the aforementioned liquid-crystal layer in the field which counters two or more 1st openings of the above formed in the 1st electrode of the above of the voltage impressed between the 1st electrode of the above and the 2nd electrode of the above takes a radial inclination orientation state, respectively

[Claim 11] the field corresponding to at least one liquid crystal domain of the liquid crystal domain of the aforementioned plurality [substrate / 2nd / of the above] -- the above -- the liquid crystal display according to claim 10 which has further the orientation regulation structure which discovers the orientation restraining force to which radial inclination orientation of the liquid crystal molecule in one liquid crystal domain is carried out in a voltage impression state at least even if few

[Claim 12] the aforementioned orientation regulation structure -- the above -- the liquid crystal display according to claim 11 formed in the field corresponding to near the center of one liquid crystal domain even if few

[Claim 13] the above -- the liquid crystal display according to claim 11 or 12 which adjusts the orientation regulation direction by the aforementioned orientation regulation structure even if few with the direction of the aforementioned radial inclination orientation in one liquid crystal domain

[Claim 14] The aforementioned orientation regulation structure is a liquid crystal display given in either of the claims 11-13 which discovers the orientation restraining force to which radial inclination orientation of the liquid crystal molecule is carried out also in voltage the state where it does not impress.

[Claim 15] The aforementioned orientation regulation structure is a liquid crystal display according to claim 14 which is the heights which projected to the aforementioned liquid crystal layer side of the 2nd substrate of the above.

[Claim 16] The aforementioned orientation regulation structure is a liquid crystal display including the front face of a level stacking tendency established in the aforementioned liquid crystal layer side of the 2nd substrate of the above according to claim 14.

[Claim 17] The aforementioned orientation regulation structure is a liquid crystal display given in either of the claims 11-13 which discovers the orientation restraining force to which radial inclination orientation of the liquid crystal molecule is carried out only in a voltage impression state.

[Claim 18] The aforementioned orientation regulation structure is a liquid crystal display containing opening prepared in the 2nd electrode of the above according to claim 17.

[Claim 19] It is a liquid crystal display given in either of the claims 1-18 which has the polarizing plate of the prepared couple further so that it may counter mutually through the aforementioned liquid crystal layer and by which the polarizing plate of the aforementioned couple is arranged at the cross Nicol's prism state.

[Claim 20] It is the liquid crystal display according to claim 19 with which it has the quadrant wavelength plate of the prepared couple further so that it may counter mutually through the aforementioned liquid crystal layer, and each of the quadrant wavelength plate of the aforementioned couple is arranged between the aforementioned liquid crystal layer and each of the polarizing plate of the aforementioned couple.

[Claim 21] It is the liquid crystal display according to claim 20 with which it has further 1/2 wavelength plate of the prepared couple so that it may counter mutually through the aforementioned liquid crystal layer, and each of 1/2 wavelength plate of the aforementioned couple is arranged between each of the polarizing plate of the aforementioned couple, and each of the quadrant wavelength plate of the aforementioned couple.

[Claim 22] The lagging axis of the quadrant wavelength plate of the aforementioned couple is a liquid crystal display according to claim 20 or 21 arranged so that it may intersect perpendicularly mutually.

[Claim 23] The lagging axis of 1/2 wavelength plate of the aforementioned couple is a liquid crystal display given in either of the claims 20-22 which is arranged so that it may intersect perpendicularly mutually.

[Claim 24] Each aforementioned liquid crystal layer in two or more aforementioned picture element fields is a liquid crystal display given in either of the claims 20-23 which whirl with the voltage impressed between the 1st electrode of the above, and the 2nd electrode of the above, and take an orientation state.

[Claim 25] Each aforementioned liquid crystal layer in two or more aforementioned picture element fields is a liquid crystal display including the minute field which takes the twist orientation state where the aforementioned liquid crystal layer was met with the voltage impressed between the 1st electrode of the above, and the 2nd electrode of the above according to claim 24.

[Claim 26] The 1st substrate of the above is a liquid crystal display given in either of the claims 1-25 which are at least one counterelectrode to which it is the picture element electrode which it has further the active element prepared corresponding to each of two or more aforementioned picture element fields, and the 1st electrode of the above is prepared for two or more aforementioned picture element fields of every, and is switched by the aforementioned active element, and the 2nd electrode of the above counters two or more aforementioned picture element electrodes.

[Claim 27] The 1st electrode which has the liquid crystal layer prepared between the 1st substrate, the 2nd substrate, and the 1st substrate of the above and the 2nd substrate of the above, and was prepared in the aforementioned liquid crystal layer side of the 1st substrate of the above, By the 2nd electrode which is prepared in the 2nd substrate of the above and counters the 1st electrode of the above through the aforementioned liquid crystal layer, it has two or more picture element fields where each is specified. the 1st electrode of the above Prepare a part of lower layer conductive layer and aforementioned lower layer conductive layer [at least] in the aforementioned wrap dielectric-layer and liquid crystal layer side of the aforementioned dielectric layer, have the **** upper conductive layer, and it sets to each of two or more aforementioned picture element fields. The aforementioned upper conductive layer has two or more openings and solid sections. the aforementioned liquid crystal layer When a perpendicular orientation state is taken when voltage is not impressed between the 1st electrode of the above, and the 2nd electrode of the above, and voltage is impressed between the 1st electrode of the above, and the 2nd electrode of the above By the slanting electric field generated by the edge section of two or more aforementioned openings of the aforementioned upper conductive layer

The liquid crystal display which displays when each forms in opening or the aforementioned solid section of the aforementioned plurality two or more liquid crystal domains which take a radial inclination orientation state and the orientation state of two or more aforementioned liquid crystal domains changes according to the impressed voltage.
[Claim 28] A part of [at least] openings of two or more aforementioned openings are liquid crystal displays according to claim 27 which form at least one unit lattice arranged so that it may be an equal configuration, it may have an equal size substantially and it may have symmetry-of-revolution nature.
[Claim 29] the above of two or more aforementioned openings -- the liquid crystal display according to claim 28 with which each configuration of a part of openings has symmetry-of-revolution nature even if few
[Claim 30] the above of two or more aforementioned openings -- the liquid crystal display according to claim 28 or 29 whose each of a part of openings is an approximate circle form even if few
[Claim 31] the aforementioned solid section -- the above -- a liquid crystal display given in either of the claims 28-30 whose each of two or more aforementioned unit solid sections it has two or more unit solid sections in which each was substantially surrounded by a part of openings even if few, and is an approximate circle form
[Claim 32] Setting to each of two or more aforementioned picture element fields, the sum total of the area of two or more aforementioned openings of the 1st electrode of the above is a liquid crystal display given in either smaller than the area of the aforementioned solid section of the 1st electrode of the above of the claims 27-31.
[Claim 33] The side of the aforementioned heights is a liquid crystal display to a publication in either of the claims 27-32 which has the orientation restraining force of the same direction as the orientation regulation direction the cross-section configuration of the field inboard of the 1st substrate of the above of the aforementioned heights is the same as the configuration of two or more aforementioned openings, and according to the aforementioned slanting electric field to the liquid crystal molecule of the aforementioned liquid crystal layer by having heights further inside [each] two or more aforementioned openings.
[Claim 34] The 1st substrate of the above is a liquid crystal display given in either of the claims 27-33 which are at least one counterelectrode to which it is the picture element electrode which it has further the active element prepared corresponding to each of two or more aforementioned picture element fields, and the 1st electrode of the above is prepared for two or more aforementioned picture element fields of every, and is switched by the aforementioned active element, and the 2nd electrode of the above counters two or more aforementioned picture element electrodes.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] About a liquid crystal display, especially this invention has a property for a wide-field-of-view angle, and relates to the liquid crystal display which displays high display grace.
[0002]
[Description of the Prior Art] as the display used for the display of a personal computer, or the display of a Personal Digital Assistant device in recent years -- a thin shape -- the lightweight liquid crystal display is used However, it has the fault that the conventional twist nematic type (TN type) and a super twist nematic type (STN type) liquid crystal display have a narrow angle of visibility, and various ED is performed in order to solve it.
[0003] There is a method which adds an optical compensating plate as typical technology for improving the angle-of-visibility property of the liquid crystal display of TN type or a STN type. There is a horizontal electric-field method which impresses horizontal electric field to a liquid crystal layer to the front face of a substrate as other methods. the liquid crystal display of this horizontal electric-field method -- recent years -- **** -- it is-izing and observed moreover, using the nematic-liquid-crystal material which has a negative dielectric constant anisotropy as a liquid crystal material as other technology, it considers as an orientation film and there is a DAP (deformation of vertical aligned phase) using a perpendicular orientation film This is one of the armature-voltage control birefringence (ECB:electrically controlled birefringence) methods, and controls permeability using the form birefringence of a liquid crystal molecule.
[0004]
[Problem(s) to be Solved by the Invention] however, although it is one of the effective methods as wide-field-of-view cornification technology, in a manufacture process, a horizontal electric-field method is compared with the usual TN type, and since a production margin is remarkable and narrow, it has the problem which will be said if stable production is difficult This needs the further ED, in order for the gap of the direction of a transparency shaft (polarization shaft) of a polarizing plate to the gap unevenness between substrates or the orientation shaft of a liquid crystal molecule to be for influencing display brightness and a contrast ratio greatly, to control these with high precision and to perform stable production.
[0005] Moreover, in order for the liquid crystal display of a DAP method to perform the uniform display without display nonuniformity, it is necessary to perform orientation control. There is the method of carrying out orientation processing by carrying out rubbing of the front face of an orientation film as the method of orientation control. However, if rubbing processing is performed to a perpendicular orientation film, it is not [that it is easy to generate a rubbing line in a display image] suitable for mass production.
[0006] As a method of on the other hand performing orientation control, without performing rubbing processing, by forming a slit (opening) in an electrode, slanting electric field are generated and the method of controlling the direction of orientation of a liquid crystal molecule by the slanting electric field is also devised (for example, JP,6-301036,A). However, the invention-in-this-application person's examination showed that there was the following problem in this method.
[0007] When the composition which generates slanting electric field by forming a slit (opening) in an electrode is adopted, sufficient voltage for the liquid crystal layer of the field corresponding to the slit formed in the electrode cannot be impressed, orientation of the liquid crystal molecule of the liquid crystal layer of the field corresponding to a slit cannot fully be controlled, but there is a problem that the loss of the permeability at the time of voltage impression arises.
[0008] this invention was made in order to solve the above-mentioned problem, and it aims at offering the high liquid crystal display and its manufacture method of display grace.

[0009]
[Means for Solving the Problem] The 1st electrode which the liquid crystal display of this invention has the liquid crystal layer prepared between the 1st substrate, the 2nd substrate, and the 1st substrate of the above and the 2nd substrate of the above, and was prepared in the aforementioned liquid crystal layer side of the 1st substrate of the above, It has two or more picture element fields specified by the 2nd electrode which is prepared in the 2nd substrate of the above and counters the 1st electrode of the above through the aforementioned liquid crystal layer. each liquid crystal layer in two or more aforementioned picture element fields An orientation state is changed according to the voltage which took the perpendicular orientation state when voltage was not impressed between the 1st electrode of the above, and the 2nd electrode of the above, and was impressed between the 1st electrode of the above, and the 2nd electrode of the above. the 1st electrode of the above A lower layer conductive layer, Prepare a part of aforementioned lower layer conductive layer [at least] in the aforementioned wrap dielectric-layer and liquid crystal layer side of the aforementioned dielectric layer, and it has the **** upper conductive layer. the aforementioned upper conductive layer -- 1st at least one opening -- having -- and the aforementioned lower layer conductive layer -- the aforementioned dielectric layer -- minding -- the above -- it is prepared so that it may counter with a part of 1st one opening [at least], even if few, and the above-mentioned purpose is attained by that The upper conductive layer which has the 1st opening generates slanting electric field in the edge section of the 1st opening, and it acts so that radial inclination orientation of the liquid crystal molecule may be carried out. Moreover, since the electric field by the lower layer conductive layer are impressed to the field which counters the 1st opening, the orientation of the liquid crystal molecule located on the 1st opening is stabilized.
[0010] the aforementioned lower layer conductive layer -- the aforementioned dielectric layer -- minding -- the above -- it is desirable to be prepared in the field including the field which counters the 1st one opening even if few Electric field can be made to act effective in the liquid crystal layer located on the 1st opening.
[0011] the above -- even if few, the 1st one opening may be a square, and it may be circular
[0012] the above which the aforementioned upper conductive layer has -- it is desirable that the 1st one opening is two or more 1st openings even if few If the composition which has two or more 1st openings is adopted, the whole picture element field can be covered and stable radial inclination orientation can be made to form. Moreover, the fall of a speed of response can be suppressed.
[0013] As for two or more 1st openings of the above which the aforementioned upper conductive layer has, being arranged regularly is desirable. It is desirable to arrange two or more 1st openings of the above so that it may have symmetry-of-revolution nature especially.
[0014] the aforementioned dielectric layer -- the above -- it is good also as composition which has a crevice or a hole in the 1st one opening even if few If the composition which has a crevice or a hole is adopted as a dielectric layer, the voltage drop by the dielectric layer can be suppressed. Moreover, liquid crystal layer thickness can also be adjusted.
[0015] The aforementioned lower layer conductive layer is good also as composition which has the 2nd opening in the field which counters the 1st opening of the above. The 2nd opening acts so that the center of the radial inclination orientation of the liquid crystal layer in the 1st opening may be stabilized.
[0016] Either the aforementioned upper conductive layer or the aforementioned lower layer conductive layers are transparent conductive layers, and another side is good also as composition which is a reflective conductive layer. If the composition which makes the upper conductive layer a reflector and makes a lower layer conductive layer a transparent electrode especially is adopted, it will become possible to optimize the display property of the transparent mode, and the display property in reflective mode, respectively.
[0017] the above which the aforementioned upper conductive layer has -- even if few, the 1st one opening is two or more 1st openings, and it is desirable to consider as the composition in which the aforementioned liquid-crystal layer in the field which counters two or more 1st openings of the above formed in the 1st electrode of the above with the voltage impressed between the 1st electrode of the above and the 2nd electrode of the above forms two or more liquid-crystal domains which take a radial inclination orientation state, respectively
[0018] the field corresponding to at least one liquid crystal domain of the liquid crystal domain of the aforementioned plurality [substrate / 2nd / of the above] -- the above -- it is good also as composition which has further the orientation regulation structure which discovers the orientation restraining force to which radial inclination orientation of the liquid crystal molecule in one liquid crystal domain is carried out in a voltage impression state at least even if few
[0019] the aforementioned orientation regulation structure -- the above -- it is desirable to be prepared in the field corresponding to near the center of one liquid crystal domain even if few
[0020] the above -- as for the orientation regulation direction by the aforementioned orientation regulation structure even if few, it is desirable in one liquid crystal domain to have consistency with the direction of the aforementioned radial inclination orientation

[0021] The aforementioned orientation regulation structure is good also in voltage the state where it does not impress, also as composition which discovers the orientation restraining force to which radial inclination orientation of the liquid crystal molecule is carried out.
[0022] The aforementioned orientation regulation structure may be the heights which projected to the aforementioned liquid crystal layer side of the 2nd substrate of the above.
[0023] The aforementioned orientation regulation structure may be composition including the front face of a level stacking tendency established in the aforementioned liquid crystal layer side of the 2nd substrate of the above.
[0024] The aforementioned orientation regulation structure may be composition which discovers the orientation restraining force to which radial inclination orientation of the liquid crystal molecule is carried out only in a voltage impression state.
[0025] The aforementioned orientation regulation structure may be the composition containing opening prepared in the 2nd electrode of the above.
[0026] It has the polarizing plate of the prepared couple further so that it may counter mutually through the aforementioned liquid crystal layer, and the polarizing plate of the aforementioned couple is good also as composition arranged at a cross Nicol's prism state.
[0027] It has the quadrant wavelength plate of the prepared couple further so that it may counter mutually through the aforementioned liquid crystal layer, and as for each of the quadrant wavelength plate of the aforementioned couple, it is desirable to consider as the composition arranged between the aforementioned liquid crystal layer and each of the polarizing plate of the aforementioned couple.
[0028] 1/2 wavelength plate of the couple prepared so that it might counter mutually through the aforementioned liquid crystal layer -- further -- having -- each of 1/2 wavelength plate of the aforementioned couple -- the polarizing plate of the aforementioned couple -- respectively -- ** -- the quadrant wavelength plate of the aforementioned couple -- respectively -- ** -- considering as the composition arranged in between is still more desirable
[0029] As for the lagging axis of the quadrant wavelength plate of the aforementioned couple, it is desirable to be arranged so that it may intersect perpendicularly mutually.
[0030] As for the lagging axis of 1/2 wavelength plate of the aforementioned couple, it is desirable to be arranged so that it may intersect perpendicularly mutually.
[0031] As for each aforementioned liquid crystal layer in two or more aforementioned picture element fields, it is desirable to consider as the composition which whirls with the voltage impressed between the 1st electrode of the above and the 2nd electrode of the above, and takes an orientation state.
[0032] As for each aforementioned liquid crystal layer in two or more aforementioned picture element fields, it is still more desirable to include the minute field which takes a twist orientation state along with the aforementioned liquid crystal layer with the voltage impressed between the 1st electrode of the above and the 2nd electrode of the above.
[0033] The 1st substrate of the above has further the active element prepared corresponding to each of two or more aforementioned picture element fields, it is the picture element electrode which the 1st electrode of the above is prepared for two or more aforementioned picture element fields of every, and is switched by the aforementioned active element, and its 2nd electrode of the above is good also as composition which is at least one counterelectrode which counters two or more aforementioned picture element electrodes. A counterelectrode is a typically single electrode.
[0034] The 1st electrode which other liquid crystal displays by this invention have the liquid crystal layer prepared between the 1st substrate, the 2nd substrate, and the 1st substrate of the above and the 2nd substrate of the above, and was prepared in the aforementioned liquid crystal layer side of the 1st substrate of the above, By the 2nd electrode which is prepared in the 2nd substrate of the above and counters the 1st electrode of the above through the aforementioned liquid crystal layer, it has two or more picture element fields where each is specified. the 1st electrode of the above Prepare a part of lower layer conductive layer and aforementioned lower layer conductive layer [at least] in the aforementioned wrap dielectric-layer and liquid crystal layer side of the aforementioned dielectric layer, have the **** upper conductive layer, and it sets to each of two or more aforementioned picture element fields. The aforementioned upper conductive layer has two or more openings and solid sections. the aforementioned liquid crystal layer When a perpendicular orientation state is taken when voltage is not impressed between the 1st electrode of the above, and the 2nd electrode of the above, and voltage is impressed between the 1st electrode of the above, and the 2nd electrode of the above By the slanting electric field generated by the edge section of two or more aforementioned openings of the aforementioned upper conductive layer It has the composition which displays when each forms in opening or the aforementioned solid section of the aforementioned plurality two or more liquid crystal domains which take a radial inclination orientation state and the orientation state of two or more aforementioned liquid crystal domains changes according to the impressed voltage, and the above-mentioned purpose is attained by that.
[0035] As for a part of [at least] openings of two or more aforementioned openings, it is desirable to form at least one

unit lattice arranged so that it may be an equal configuration, it may have an equal size substantially and it may have symmetry-of-revolution nature.
[0036] the above of two or more aforementioned openings -- it is desirable that each configuration of a part of openings has symmetry-of-revolution nature even if few
[0037] the above of two or more aforementioned openings -- even if few, each of a part of openings may be an approximate circle form
[0038] the aforementioned solid section -- the above -- it may have two or more unit solid sections in which each was substantially surrounded by a part of openings even if few, and each of two or more aforementioned unit solid sections may be an approximate circle form
[0039] As for the sum total of the area of two or more aforementioned openings of the 1st electrode of the above, in each of two or more aforementioned picture element fields, it is desirable that it is smaller than the area of the aforementioned solid section of the 1st electrode of the above.
[0040] It has heights further inside [each] two or more aforementioned openings, and the cross-section configuration of the field inboard of the aforementioned substrate of the aforementioned heights is the same as the configuration of two or more aforementioned openings, and the side of the aforementioned heights is good also as composition which has the orientation restraining force of the same direction as the orientation regulation direction by the aforementioned slanting electric field to the liquid crystal molecule of the aforementioned liquid crystal layer.
[0041] The 1st substrate of the above has further the active element prepared corresponding to each of two or more aforementioned picture element fields, it is the picture element electrode which the 1st electrode of the above is prepared for two or more aforementioned picture element fields of every, and is switched by the aforementioned active element, and its 2nd electrode of the above is good also as composition which is at least one counterelectrode which counters two or more aforementioned picture element electrodes. A counterelectrode is a typically single electrode.
[0042]
[Embodiments of the Invention] Hereafter, the operation gestalt of this invention is explained, referring to a drawing.
[0043] (Operation gestalt 1) The electrode structure which the liquid crystal display of this invention has, and its operation are explained first. Since it has the outstanding display property, the liquid crystal display by this invention is used suitable for active matrix liquid crystal display. Below, the operation gestalt of this invention is explained about the active matrix liquid crystal display which used TFT (TFT). this invention is not restricted to this but can be applied to the active matrix liquid crystal display and simple matrix liquid crystal display using MIM. Moreover, below, although the operation gestalt of this invention is explained to an example, this invention is not restricted to this but can apply a penetrated type liquid crystal display to a reflected type liquid crystal display and the transparency reflective two-ways type liquid crystal display mentioned further later.
[0044] In addition, in this application specification, the field of the liquid crystal display corresponding to the "picture element" which is the smallest unit of a display is called "picture element field." In electrochromatic display display, the "picture element" of R, G, and B corresponds to one a "pixel." The counterelectrode which a picture element field counters with a picture element electrode and a picture element electrode in active matrix liquid crystal display specifies a picture element field. Moreover, in simple matrix liquid crystal display, each field where the line electrode prepared so that it may intersect perpendicularly with the train electrode and train electrode which are prepared in the shape of a stripe crosses mutually specifies a picture element field. In addition, in the composition in which a black matrix is prepared, the field corresponding to opening of a black matrix will be equivalent to a picture element field among the fields where voltage is strictly impressed according to the state where it should display.
[0045] The cross section of one picture element field of the liquid crystal display 100 of the operation gestalt by this invention is typically shown in drawing 1 . Below, a light filter and a black matrix are omitted for the simplicity of explanation. Moreover, in the following drawings, the same reference mark shows the component of a liquid crystal display 100, and the component which has the same function substantially, and the explanation is omitted. In addition, for intelligibility although [drawing 1] one picture element field of a liquid crystal display 100 is shown, the liquid crystal display by this invention should just have the electrode composition shown in drawing 1 in [at least one] one picture element field so that it may explain in full detail behind.
[0046] The liquid crystal display 100 has the liquid crystal layer 30 prepared between active-matrix substrate (it is called "TFT substrate" below.) 100a, opposite substrate (it is called "light-filter substrate") 100b, and TFT substrate 100a and opposite substrate 100b. Liquid crystal molecule 30a of the liquid crystal layer 30 has a negative dielectric constant anisotropy, and by the perpendicular orientation layer (un-illustrating) prepared in the front face by the side of the liquid crystal layer 30 of TFT substrate 100a and opposite substrate 100b, when voltage is not impressed to the liquid crystal layer 30, as shown in drawing 1 (a), it carries out orientation perpendicularly to the front face of a perpendicular orientation film. At this time, it is said that the liquid crystal layer 30 is in a perpendicular orientation

state. However, liquid crystal molecule 30a of the liquid crystal layer 30 in a perpendicular orientation state may incline a little from the normal of the front face (front face of a substrate) of a perpendicular orientation film according to the kind of perpendicular orientation film, or the kind of liquid crystal material. Generally, the state where the liquid crystal molecule shaft (it is called "an axial direction".) carried out orientation at the angle of about 85 degrees or more is called perpendicular orientation state to the front face of a perpendicular orientation film.
[0047] TFT substrate 100a of a liquid crystal display 100 has the transparent substrate (for example, glass substrate) 11 and the picture element electrode 15 formed in the front face. Opposite substrate 100b has the transparent substrate (for example, glass substrate) 21 and the counterelectrode 22 formed in the front face. According to the voltage impressed to the picture element electrode 15 arranged so that it may counter mutually through the liquid crystal layer 30, and a counterelectrode 22, the orientation state of the liquid crystal layer 30 for every picture element field changes. A display is performed with change of the orientation state of the liquid crystal layer 30 using the phenomenon in which the polarization state and amount of the light which penetrates the liquid crystal layer 30 change.
[0048] The picture element electrode 15 which a liquid crystal display 100 has forms a part of lower layer conductive layer 12 and lower layer conductive layer [at least] 12 in the wrap dielectric-layer 13 and liquid crystal layer 30 side of a dielectric layer, and has the **** upper conductive layer 14. The lower layer conductive layer 12 is formed in the field including all the fields on the substrate 11 which counters opening 14a in the liquid crystal display 100 shown in drawing 1 (area of area > opening 14a of the lower layer conductive layer 12).
[0049] In addition, the composition of the picture element electrode 15 in the liquid crystal display of this operation form is not restricted to the above-mentioned example, but may form the lower layer conductive layer 12 in the field on the substrate 11 which counters opening 14a like liquid crystal display 100' shown in drawing 2 (a) (area of area = opening 14a of the lower layer conductive layer 12). Moreover, you may form the lower layer conductive layer 12 in the field on the liquid crystal display 100' substrate 11 which counters opening 14a like 'shown in drawing 2 (b) (area of area < opening 14a of the lower layer conductive layer 12). Namely, the lower layer conductive layer 12 should just be formed so that it may counter with a part of opening 14a [at least] through a dielectric layer 13. however, the inside of the flat surface which the lower layer conductive layer 12 looked at from [of a substrate 11] the normal in the composition (drawing 2 (b)) formed in opening 14a -- both the lower layer conductive layer 12 and the upper conductive layer 14 -- although -- the field (crevice field) not existing exists and sufficient voltage for the liquid crystal layer 30 of the field which counters this crevice field may not be impressed Therefore, it is desirable to make narrow enough width of face (WS in drawing 2 (b)) of this crevice field so that the orientation of the liquid crystal layer 30 may be stabilized. As for WS, typically, it is desirable not to exceed about 4 micrometers.
[0050] In addition, the picture element electrode 15 equipped with the lower layer conductive layer 12 and the upper conductive layer 14 may be called "two-layer structure electrode." A "lower layer" and the "upper layer" are the terms used since the relative relation to the dielectric layer 13 of two electrodes 12 and 14 was expressed, and do not restrict the spatial arrangement at the time of use of a liquid crystal display. Furthermore, a "two-layer structure electrode" should just be the composition of not eliminating the composition which has electrodes other than lower layer conductive-layer 12 and upper conductive-layer 14, having the lower layer conductive layer 12 and the upper conductive layer 14 at least, and having the operation explained below. Moreover, a two-layer structure electrode does not need to be a picture element electrode in a TFT type liquid crystal display, and if it has a two-layer structure electrode for every picture element field, it may be applied also to the liquid crystal display of other types. Specifically, if the train electrode (signal electrode) in simple matrix liquid crystal display has two-layer structure for every picture element field, the train electrode in a picture element field will function as a two-layer structure electrode.
[0051] Next, it explains, comparing with operation of the liquid crystal display equipped with the electrode of other composition of operation of a liquid crystal display equipped with a two-layer structure electrode while referring to drawing 1 , drawing 3 , and drawing 4 .
[0052] First, operation of a liquid crystal display 100 is explained, referring to drawing 1 .
[0053] Drawing 1 (a) shows typically the orientation state (OFF state) of liquid crystal molecule 30a in the liquid crystal layer 30 to which voltage is not impressed. Drawing 1 (b) shows typically the state (ON initial state) where the orientation of liquid crystal molecule 30a began to change, according to the voltage impressed to the liquid crystal layer 30. Drawing 1 (c) shows typically the state where the orientation of liquid crystal molecule 30a which changed according to the impressed voltage reached the steady state. Drawing 1 shows the example which impressed the same voltage to the lower layer conductive layer 12 and the upper conductive layer 14 which constitute the picture element electrode 15 for simplicity. The curve EQ in drawing 1 (b) and (c) shows the equipotential line EQ.
[0054] As shown in drawing 1 (a), when the picture element electrode 15 and a counterelectrode 22 are these potentials (state where voltage is not impressed to the liquid crystal layer 30), orientation of the liquid crystal molecule 30a in a picture element field is perpendicularly carried out to the front face of both the substrates 11 and 21.

[0055] If voltage is impressed to the liquid crystal layer 30, the electric potential gradient expressed with potential line EQ(it intersects perpendicularly with line of electric force) EQ, such as having been shown in drawing 1 (b), will be formed. In the liquid crystal layer 30 located between the upper conductive layer 14 of the picture element electrode 15, and a counterelectrode 22, the uniform electric potential gradient expressed with the parallel equipotential line EQ to the front face of the upper conductive layer 14 and a counterelectrode 22 is formed. The electric potential gradient according to the potential difference of the lower layer conductive layer 12 and a counterelectrode 22 is formed in the liquid crystal layer 30 located on opening 14a of the upper conductive layer 14. Since the electric potential gradient formed in the liquid crystal layer 30 is influenced of the voltage drop (capacitive component rate) by the dielectric layer 13 at this time, the equipotential line EQ formed in the liquid crystal layer 30 falls in the field corresponding to opening 14a (a "valley" is formed in the equipotential line EQ). It is a field corresponding to opening 14a, and that a part of equipotential line EQ has invaded in a dielectric layer 13 means that the voltage drop (capacitive component rate) has arisen by the dielectric layer 13. Since the lower layer conductive layer 12 is formed in the field which counters opening 14a through a dielectric layer 13, the electric potential gradient expressed with the parallel equipotential line EQ to the field of the upper conductive layer 14 and a counterelectrode 22 is formed also in the liquid crystal layer 30 located on near the center of opening 14a ("bottom of a valley" of the equipotential line EQ). In the liquid crystal layer 30 on the edge section (inside circumference of opening 14a including the boundary (extent) of opening 14a) EG of opening 14a, the slanting electric field expressed with the potential line EQ, such as having inclined, are formed.
[0056] The torque which is going to carry out orientation of the axial direction of liquid crystal molecule 30a to parallel (perpendicular to line of electric force) to the equipotential line EQ acts on liquid crystal molecule 30a which has a negative dielectric anisotropy. Therefore, as the arrow showed liquid crystal molecule 30a on the edge section EG in drawing 1 (b), in the right-hand side edge section EG in drawing, it carries out in the direction of a clockwise rotation, and inclines in the direction of a counterclockwise rotation in the left-hand side edge section EG in drawing, respectively (rotation), and orientation is carried out in parallel with the equipotential line EQ.
[0057] Here, change of the orientation of liquid crystal molecule 30a is explained in detail, referring to drawing 5 .
[0058] If electric field are generated by the liquid crystal layer 30, the torque to which orientation of the axial direction tends to be carried out in parallel to the equipotential line EQ will act on liquid crystal molecule 30a which has a negative dielectric constant anisotropy. If the electric field expressed with the perpendicular equipotential line EQ to the axial direction of liquid crystal molecule 30a occur as shown in drawing 5 (a), it will act on liquid crystal molecule 30a by the probability that the torque which makes it incline in a clockwise rotation or the direction of a counterclockwise rotation is equal. Therefore, in the parallel monotonous liquid crystal layer 30 in inter-electrode [of type arrangement] which counters mutually, liquid crystal molecule 30a which receives the torque of the direction of a clockwise rotation, and liquid crystal molecule 30a which receives the torque of a direction in a counterclockwise rotation are intermingled so that it may mention later, referring to drawing 3 . Consequently, change in the orientation state according to the voltage impressed to the liquid crystal layer 30 may not take place smoothly.
[0059] If the electric field (slanting electric field) expressed with the potential line EQ, such as having inclined to the axial direction of liquid crystal molecule 30a, in the edge section EG of opening 14a of the liquid crystal display 100 by this invention occur as shown in drawing 1 (b), as shown in drawing 5 (b), liquid crystal molecule 30a inclines in the direction (the example of illustration counterclockwise rotation) with few amounts of inclinations for becoming the equipotential line EQ and parallel. Moreover, as shown in drawing 5 (c), the liquid-crystal molecule 30 a located in the field which the electric field expressed with the perpendicular equipotential line EQ to the axial direction of liquid-crystal molecule 30a generate inclines in the same direction as liquid-crystal molecule 30a located on the potential line EQ, such as having inclined, so that liquid-crystal molecule 30a and the orientation which are located on the potential line EQ, such as having inclined, may become continuously (it has consistency like). In addition, what "is located in the electric field expressed with the equipotential line EQ", saying "it is located on the equipotential line EQ" is meant.
[0060] If change of the orientation which begins from liquid crystal molecule 30a located on the potential line EQ, such as having inclined, progresses and a steady state is reached as mentioned above, it will be in the orientation state typically shown in drawing 1 (c). Liquid crystal molecule 30a located near the center of opening 14a Since it is influenced almost equally of the orientation of liquid crystal molecule 30a of the edge section EG of the both sides which counter mutually [opening 14a] Maintaining a perpendicular orientation state to the equipotential line EQ, liquid crystal molecule 30a of a field which is distant from the center of opening 14a inclines in response to the influence of the orientation of liquid crystal molecule 30a of the edge section EG of the respectively nearer one, and forms symmetrical inclination orientation about the center SA of opening 14a. This orientation state is in the state where the axial direction of liquid crystal molecule 30a carried out orientation to the radial about the center of opening 14a, seen from a direction (direction perpendicular to the front face of substrates 11 and 21) perpendicular to the screen

of a liquid crystal display 100 (un-illustrating). Then, in this application specification, such an orientation state will be called "radial inclination orientation."
[0061] In order to improve the viewing-angle dependency of a liquid crystal display in an omnidirection, it is desirable to have the symmetry-of-revolution nature centering on the shaft of the direction where the orientation of the liquid crystal molecule in each picture element field is perpendicular to the screen, and it is still more desirable to have axial-symmetry nature. Therefore, as for opening 14a, it is desirable to be arranged so that the orientation of the liquid crystal layer 30 of a picture element field may have symmetry-of-revolution nature (or axial-symmetry nature). When forming one opening 14a for every picture element field, it is desirable to prepare opening 14a in the center of a picture element field. Moreover, also as for the configuration (configuration in the stratification plane of the liquid crystal layer 30) of opening 14a, it is desirable to have symmetry-of-revolution nature (axial-symmetry nature), and it is desirable. [of regular polygons such as a square, or a circular thing] About the arrangement in the case of forming two or more opening 14a in a picture element field, it mentions later.
[0062] Drawing 1 (a) As explained referring to - (c), the liquid crystal display 100 by this invention has the two-layer structure electrode 15 for every picture element field, and generates the electric field expressed with the potential line EQ, such as having the field which inclined in the liquid crystal layer 30 in a picture element field. Liquid crystal molecule 30a which has a negative dielectric anisotropy in the liquid crystal layer 30 which is in a perpendicular orientation state at the time of no voltage impressing changes the direction of orientation by making into a trigger orientation change of liquid crystal molecule 30a located on the potential line EQ, such as having inclined, and forms stable radial inclination orientation. of course -- drawing 2 -- (-- a --) -- and -- (-- b --) -- having been shown -- a liquid crystal display -- 100 -- ' -- and -- 100 -- ' -- ' -- the same -- operating . However, in the composition of drawing 2 (b), when the crevice field WS becomes not much large, sufficient voltage for the edge section of opening 14a will not be impressed (if about 5 micrometers is exceeded), but it may become the field which does not contribute to a display.
[0063] Next, operation of the conventional typical liquid crystal display 200 is explained, referring to drawing 3 . Drawing 3 (a) - (c) shows typically one picture element field of a liquid crystal display 200.
[0064] A liquid crystal display 200 has picture element electrode 15A and the counterelectrode 22 which have been arranged so that it may counter mutually. Picture element electrode 15A and the counterelectrode 22 are formed from the single conductive layer which all does not have opening 14a.
[0065] As shown in drawing 3 (a), when voltage is not impressed to the liquid crystal layer 30, the liquid crystal layer 30 takes a perpendicular orientation state.
[0066] As shown in drawing 3 (b), the electric field generated by impressing voltage to the liquid crystal layer 30 cover the whole picture element field, and are expressed with the parallel equipotential line EQ to the front face of picture element electrode 15A and a counterelectrode 22. Although liquid crystal molecule 30a tends to change the direction of orientation at this time so that an axial direction may become parallel to the equipotential line EQ, as shown at drawing 5 (a) under the electric field electric field, and the axial direction and the equipotential line EQ of liquid crystal molecule 30a cross at right angles, the direction where liquid crystal molecule 30a inclines (rotation) does not become settled uniquely. Liquid crystal molecule 30a is typically influenced by the local surface state of a perpendicular orientation film of a difference, and begins to incline in the various directions. Consequently, the orientation states of liquid crystal molecule 30a will differ among two or more picture element fields, and the display by the liquid crystal display 200 will be the rough display. Moreover, time longer than the liquid crystal display 100 of this invention mentioned above by the time the orientation state of the liquid crystal layer 30 reached the steady state shown in drawing 3 (c) is needed.
[0067] That is, the liquid crystal display 100 of this invention has the feature that a speed of response is quick, possible [the high-definition display without a rough deposit] as compared with the conventional liquid crystal display 200.
[0068] Next, operation of a liquid crystal display 300 which has opening 15b is explained to picture element electrode 15B, referring to drawing 4 . Picture element electrode 15B consists of single electrodes which have opening 15b, and differs from the picture element electrode 15 of the liquid crystal display of this invention in the point of not having the lower layer conductive layer 12 (for example, referring to drawing 1). A liquid crystal display 300 generates slanting electric field in the liquid crystal layer 30 like the liquid crystal display which is indicated by JP,6-301036,A mentioned above and which has opening 14a in a counterelectrode.
[0069] The liquid crystal layer 30 of a liquid crystal display 300 takes a perpendicular orientation state at the time of no voltage impressing, as shown in drawing 4 (a). The orientation state of the liquid crystal layer 30 at the time of no voltage impressing is the same as the liquid crystal display (drawing 1 and drawing 2) of this invention, or the conventional typical liquid crystal display (drawing 3).
[0070] If voltage is impressed to the liquid crystal layer 30, the electric field expressed with the potential line EQ, such as having been shown in drawing 4 (b), will be generated. Since picture element electrode 15B has opening 15b like

the picture element electrode 15 (for example, refer to drawing 1) of the liquid crystal display 100 of this operation form, the equipotential line EQ generated by the liquid crystal layer 30 of a liquid crystal display 200 falls in the field corresponding to opening 15b, and the slanting electric field expressed with the potential line EQ, such as having inclined in the liquid crystal layer 30 on the edge section EG of opening 15b, are formed. However, since picture element electrode 15B is formed from the single conductive layer and it does not have a lower layer conductive layer (the same potential as a picture element electrode) in the field corresponding to opening 15b, in the liquid crystal layer 30 located on opening 15b, the field (field on which the equipotential line EQ is not drawn) where electric field are not generated exists.

[0071] Liquid crystal molecule 30a which has the negative dielectric constant anisotropy put on the bottom of the above electric fields is served as follows. First, as the arrow showed liquid crystal molecule 30a on the edge section EG of opening 15b in drawing 4 (b), in the right-hand side edge section EG in drawing, it carries out in the direction of a clockwise rotation, and inclines in the direction of a counterclockwise rotation in the left-hand side edge section EG in drawing, respectively (rotation), and orientation is carried out in parallel with the equipotential line EQ. This can determine uniquely the inclination (rotation) direction of liquid crystal molecule 30a ** and near edge section EG which is the same behavior as liquid crystal molecule 30a in the liquid crystal display 100 of this operation form explained while referring to drawing 1 (b), and can cause orientation change stably.

[0072] However, since electric field do not occur in the liquid crystal layer 30 located on the field except the edge section EG of opening 15b, the torque which changes orientation is not generated. Consequently, even if sufficient time passes and orientation change of the liquid crystal layer 30 reaches a steady state, as shown in drawing 4 (c), the liquid crystal layer 30 located on the field except the edge section EG of opening 15b is still a perpendicular orientation state. Of course, although a part of liquid crystal molecule 30a changes orientation in response to the influence of orientation change of liquid crystal molecule 30a near edge section EG, no orientation of liquid crystal molecule 30a in the liquid crystal layer 30 on opening 15b can be changed. Although it is dependent also on the thickness of the liquid crystal layer 30, or the physical properties (the size of a dielectric constant anisotropy, elastic modulus, etc.) of liquid crystal material, whether the influence reaches to liquid crystal molecule 30a which is in the position like which from the edge of opening 15b If the distance between the fields (it is called the "solid section") which adjoin mutually through opening 15b and where a conductive layer exists in fact exceeds about 4 micrometers, liquid crystal molecule 30a near the center of opening 15b will maintain perpendicular orientation, without changing orientation with electric fields. Therefore, since the field located on opening 15b of the liquid crystal layers 30 of a liquid crystal display 300 does not contribute to a display, it causes deterioration of display grace. For example, in the display mode of a normally black, an effective numerical aperture falls and display brightness falls.

[0073] Thus, brightness becomes dark, although it can prevent the rough deposit of the display which takes place with the conventional typical liquid crystal display 200, since a liquid crystal display 300 determines uniquely the direction where the orientation of liquid crystal molecule 30a changes by the slanting electric field formed of picture element electrode 15B which has opening 15b. Since the liquid crystal display 100 of this operation form has the lower layer electrode 12 prepared so that it might counter with the upper conductive layer 14 and opening 14a which have opening 14a, it can make electric field able to act on almost all the fields of the liquid crystal layer 30 located on opening 14a, and can be made to contribute to a display. Therefore, the high-definition display which whose liquid crystal display 100 of this operation form is high brightness, and does not have a rough deposit is realizable.

[0074] The configuration (configuration seen from the substrate normal) of opening 14a which the upper conductive layer 14 of the two-layer structure electrode (picture element electrode) 15 which the liquid crystal display of this operation gestalt has has is explained. A polygon is sufficient as the configuration of opening 14a, and a round shape and an ellipse form are sufficient as it.

[0075] The display property of a liquid crystal display originates in the orientation state (optical anisotropy) of a liquid crystal molecule, and shows an azimuth dependency. In order to reduce the azimuth dependency of a display property, it is desirable that the liquid crystal molecule is carrying out orientation by equivalent probability to all azimuths. Moreover, it is still more desirable that the liquid crystal molecule in each picture element field is carrying out orientation by equivalent probability to all azimuths. Therefore, as for opening 14a, it is desirable to have a configuration in which the liquid crystal molecule in each picture element field carries out orientation by equivalent probability to all azimuths. As for the configuration of opening 14a, specifically, it is desirable to have the symmetry-of-revolution nature which sets a symmetry axis as the center (the direction of a normal) of a picture element field, respectively. It is still more desirable to have the shaft of the high symmetry-of-revolution nature more than a twofold rotation axis.

[0076] The orientation state of liquid crystal molecule 30a in case the configuration of opening 14a is a polygon is explained referring to drawing 6 (a) - drawing 6 (c). Drawing 6 (a) - (c) shows typically the orientation state of liquid

crystal molecule 30a seen from the substrate normal, respectively. It is shown that the two-layer electrode in which the edge has opening 14a rather than the other end prepares the edge where the point of liquid crystal molecule 30a drawn in the shape of an ellipse in drawing showing the orientation state of seen liquid crystal molecule 30a from [, such as drawing 6 (b) and (c),] the substrate normal is shown black, and liquid crystal molecule 30a inclines so that closely [a ******** substrate side]. Also in the following drawings, it is the same.

[0077] Here, corresponding to a rectangular (a square and a rectangle are included) picture element field, the structure in which rectangular opening 14a was formed is explained to an example. The cross section which met the 1A-1A' line in drawing 6 (a) is equivalent to drawing 1 (a), the cross section which met the 1B-1B' line in drawing 6 (b) is equivalent to drawing 1 (b), and the cross section which met the 1C-1C' line in drawing 6 (c) is equivalent to drawing 1 (c). It explains doubling and referring to drawing 1 (a) - drawing 1 (c). Of course, the configuration of a picture element field (picture element electrode 15) is not restricted to this.

[0078] When the picture element electrode 15 and counterelectrode 22 which have the lower layer conductive layer 12 and the upper conductive layer 14 are this potential, in the state where voltage is not impressed to the liquid crystal layer 30, liquid crystal molecule 30a by which the direction of orientation is regulated by the perpendicular orientation layer (un-illustrating) prepared in the liquid crystal layer 30 side front face of TFT substrate 100a and opposite substrate 100b takes a perpendicular orientation state, as shown in drawing 6 (a).

[0079] Electric field are impressed to the liquid crystal layer 30, and if the electric field expressed with the potential line EQ, such as having been shown in drawing 1 (a), occur, in liquid crystal molecule 30a which has a negative dielectric constant anisotropy, torque to which an axial direction becomes parallel to the equipotential line EQ will occur. As explained referring to drawing 5 (a) and (b), liquid crystal molecule 30a under the electric field expressed with the perpendicular equipotential line EQ to the molecule shaft of liquid crystal molecule 30a Since the direction where liquid crystal molecule 30a inclines (rotation) has not become settled uniquely (drawing 5 (a)), Since the inclination (rotation) direction is decided uniquely, as for liquid crystal molecule 30a put to change (an inclination or rotation) of orientation not taking place easily on the bottom of the potential line EQ, such as having inclined to the molecule shaft of liquid crystal molecule 30a, change of orientation takes place easily. With the structure shown in drawing 6 , liquid crystal molecule 30a begins to incline from the edge section of four sides of opening 14a of the rectangle of the upper conductive layer 14 to which the molecule shaft of liquid crystal molecule 30a leans to the equipotential line EQ. And as explained referring to drawing 5 (c), surrounding liquid crystal molecule 30a also inclines so that the orientation and adjustment of liquid crystal molecule 30a toward which the edge section of opening 14a inclined may be taken, and as shown in drawing 6 (c), the axial direction of liquid crystal molecule 30a is stabilized (radial inclination orientation).

[0080] thus, opening 14a of the upper conductive layer 14 having the shape of the shape not of a slit (it being the configuration where width of face (direction which intersects perpendicularly with length) is remarkable, and narrow, to length) but a rectangle Since liquid crystal molecule 30a inclines toward the center of opening 14a from the edge section of four sides of opening 14a at the time of voltage impression, liquid crystal molecule 30a in a picture element field Liquid crystal molecule 30a near [where the orientation restraining force of liquid crystal molecule 30a from the edge section balances] the center of opening 14a maintains the state where orientation was perpendicularly carried out to the substrate side. The state where liquid crystal molecule 30a inclined [liquid crystal molecule 30a around it] continuously in the radial focusing on liquid crystal molecule 30a near the center of opening 14a is acquired. Thus, if liquid crystal molecule 30a takes radial inclination orientation for every picture element field, to all the viewing-angle directions (the direction of an azimuth is also included), liquid crystal molecule 30a's of each axial direction existence probability becomes almost equal, and the high-definition display without a rough deposit can be realized to all the viewing-angle directions.

[0081] Furthermore, from the low (it has twofold rotation axis) rectangle of symmetry-of-revolution nature, if the configuration of opening 14a is made into the high square of symmetry-of-revolution nature (it has the axis of rotation 4 times), since the symmetric property of the radial inclination orientation of liquid crystal molecule 30a which sets a symmetry axis as the center of opening 14a becomes high, the good display which does not have a rough deposit further to the viewing-angle direction is realizable. In addition, although the rectangle was illustrated as a configuration of opening 14a, if the radial inclination orientation by which liquid crystal molecule 30a inside opening 14a was stabilized at the time of voltage impression is taken, you may be other polygons and a regular polygon with the high symmetry of revolution is still more desirable.

[0082] In addition, the radial inclination orientation of the shape of a whorl of left-handed rotation as shown in drawing 8 (b) and (c), or right-handed rotation of the radial inclination orientation of liquid crystal molecule 30a is more stable than simple radial inclination orientation as shown in drawing 8 (a). In addition, whorl-like orientation here expresses the orientation state of the liquid crystal molecule in a liquid crystal stratification plane (inside of a substrate side). The

whorl-like orientation seen when a little chiral agent is added into liquid crystal material will hardly change along the thickness direction of the liquid crystal layer 30, if the direction of orientation of liquid crystal molecule 30a hardly changes spirally along the thickness direction of the liquid crystal layer 30 like the usual twist orientation and the direction of orientation of liquid crystal molecule 30a is seen in a minute field. That is, in the cross section (cross section in a field parallel to a stratification plane) of the position of what of the thickness direction of the liquid crystal layer 30, it is in drawing 8 (b) or the same orientation state as (c), and most twist deformation which met in the thickness direction of the liquid crystal layer 30 is not produced. However, if it sees by the whole opening 14a, a certain amount of twist deformation will have occurred.

[0083] If the material which added the chiral agent is used for the nematic-liquid-crystal material which has a negative dielectric anisotropy, as shown in drawing 7 (a) and (b), respectively, liquid crystal molecule 30a will take the whorl-like radial inclination orientation of left-handed rotation or right-handed rotation focusing on opening 14a at the time of voltage impression. Right-handed rotation or left-handed rotation is decided by the kind of chiral agent to be used. Therefore, since the direction which is rolling the surroundings of liquid crystal molecule 30a which stands at right angles to the substrate side of liquid crystal molecule 30a which is carrying out the radial inclination by carrying out whorl-like radial inclination orientation of the liquid crystal layer 30 in opening 14a at the time of voltage impression can be made regularity within all opening 14a, the uniform display without a rough deposit is attained. Furthermore, since the direction which is rolling the surroundings of liquid crystal molecule 30a which stands at right angles to a substrate side has become settled, the speed of response at the time of impressing voltage to the liquid crystal layer 30 also improves.

[0084] Furthermore, also in the liquid crystal layer of a whorl orientation state, if many chiral agents are added, if its attention is paid to the minute field, the orientation of liquid crystal molecule 30a will come to change spirally along the thickness direction of the liquid crystal layer 30 like the usual twist orientation.

[0085] In the orientation state where the orientation of liquid crystal molecule 30a does not change spirally along the thickness direction of the liquid crystal layer 30, in order that a perpendicular direction or liquid crystal molecule 30a which is carrying out orientation in parallel may not give phase contrast to an incident light to the polarization shaft of a polarizing plate, the incident light which passes through the field of such an orientation state does not contribute to permeability. For example, observation of the picture element field in the white display state of a liquid crystal display where the polarizing plate has been arranged at the cross Nicol's prism state observes the quenching pattern of a cross joint clearly in the center section of the liquid crystal domain which carried out radial inclination orientation.

[0086] On the other hand, while a perpendicular direction or liquid crystal molecule 30a which is carrying out orientation in parallel also gives phase contrast to the polarization shaft of a polarizing plate to an incident light in the orientation state where the orientation of liquid crystal molecule 30a changes spirally, along the thickness direction of the liquid crystal layer 30, the optical activity of light can also be used. Therefore, since the incident light which passes through the field of such an orientation state also contributes to permeability, the liquid crystal display in which a bright display is possible can be obtained. For example, if the picture element field in the white display state of a liquid crystal display where the polarizing plate has been arranged at the cross Nicol's prism state is observed, the quenching pattern of the cross joint of the center section of the liquid crystal domain which carried out radial inclination orientation will become indefinite, and will become bright at the whole. In order to improve the use efficiency of the light by optical activity efficiently, as for the twist angle of a liquid crystal layer, it is desirable that it is about 90 degrees.

[0087] The configuration of opening 14a may not be restricted to the polygon mentioned above, but a round shape and an ellipse form are sufficient as it.

[0088] The orientation state of liquid crystal molecule 30a when the configuration of opening 14a is circular is explained referring to drawing 9 (a) - drawing 9 (c). Drawing 9 (a) - drawing 9 (c) show typically the orientation state of liquid crystal molecule 30a seen from the substrate normal, respectively. Here, the structure in which circular opening 14a was formed is explained to an example to a rectangular picture element field. The cross section which met the 1A-1A' line in drawing 9 (a) is equivalent to drawing 1 (a), the cross section which met the 1B-1B' line in drawing 9 (b) is equivalent to drawing 1 (b), and the cross section which met the 1C-1C' line in drawing 9 (c) is equivalent to drawing 1 (c). It explains doubling and referring to drawing 1 (a) - drawing 1 (c).

[0089] When the picture element electrode 15 and counterelectrode 22 which have the lower layer conductive layer 12 and the upper conductive layer 14 are this potential, in the state where voltage is not impressed to the liquid crystal layer 30, liquid crystal molecule 30a by which the direction of orientation is regulated by the perpendicular orientation layer (un-illustrating) prepared in the liquid crystal layer 30 side front face of TFT substrate 100a and opposite substrate 100b takes a perpendicular orientation state, as shown in drawing 9 (a).

[0090] Electric field are impressed to the liquid crystal layer 30, and if the electric field expressed with the potential

line EQ, such as having been shown in drawing 1 (a), occur, in liquid crystal molecule 30a which has a negative dielectric constant anisotropy, torque to which an axial direction becomes parallel to the equipotential line EQ will occur. As explained referring to drawing 5 (a) and (b), liquid crystal molecule 30a under the electric field expressed with the perpendicular equipotential line EQ to the molecule shaft of liquid crystal molecule 30a Since the direction where liquid crystal molecule 30a inclines (rotation) has not become settled uniquely (drawing 5 (a)), Since the inclination (rotation) direction is decided uniquely, as for liquid crystal molecule 30a put to change (an inclination or rotation) of orientation not taking place easily on the bottom of the potential line EQ, such as having inclined to the molecule shaft of liquid crystal molecule 30a, change of orientation takes place easily. With the structure shown in drawing 9 , liquid crystal molecule 30a begins to incline from the edge section of the periphery of circular opening 14a of the upper conductive layer 14 to which the molecule shaft of liquid crystal molecule 30a leans to the equipotential line EQ. And as explained referring to drawing 5 (c), surrounding liquid crystal molecule 30a also inclines so that the orientation and adjustment of liquid crystal molecule 30a toward which the edge section of opening 14a inclined may be taken, and the axial direction of liquid crystal molecule 30a is stabilized in the state where it was shown in drawing 9 (c) (radial inclination orientation).
[0091] Opening 14a of the upper conductive layer 14 that it is a circle configuration thus, liquid crystal molecule 30a in a picture element field Since liquid crystal molecule 30a inclines toward the center of opening 14a from the edge section of the periphery of opening 14a at the time of voltage impression Liquid crystal molecule 30a near [where the orientation restraining force of liquid crystal molecule 30a from the edge section balances] the center of opening 14a maintains the state where orientation was perpendicularly carried out to the substrate side. The state (radial inclination orientation) where liquid crystal molecule 30a inclined [liquid crystal molecule 30a around it] continuously in the radial focusing on liquid crystal molecule 30a near the center of opening 14a is acquired. When the configuration of opening 14a is circular, since the center (position of liquid crystal molecule 30a which carried out orientation at right angles to a substrate side) of radial inclination orientation is stably formed in the center of opening 14a, the high-definition display which does not have a rough deposit in all directions at the time of voltage impression can be realized rather than the case of a square.
[0092] The operation obtained when the configuration of opening 14a is circular that the center position of radial inclination orientation is stabilized is considered that it is that the symmetry-of-revolution nature of a circle is high for the edge of opening 14a which determines the direction where liquid crystal molecule 30a inclines to continue. An operation of the radial inclination orientation stabilization by the edge of opening 14a continuing is obtained also considering the configuration of opening 14a as an ellipse (ellipse).
[0093] In addition, the radial inclination orientation of liquid crystal molecule 30a is stabilized more by giving a whorl-like stacking tendency, as mentioned above, referring to drawing 8 . Therefore, it is more desirable to consider as left-handed rotation or right-handed-rotation whorl-like radial inclination orientation a center [opening 14a], as shown in drawing 10 (a) and drawing 10 (b), respectively. If the area of opening 14a becomes large and the distance from the side of opening 14a to a center becomes long especially, since the orientation of liquid crystal molecule 30a located in opening 14a will stop being stabilized easily, it is desirable to give a whorl-like stacking tendency. For example, by adding a chiral agent into liquid crystal material, it can whirl to radial orientation and orientation can be given.
[0094] [Composition which has two or more openings] Although the composition and the operation of a two-layer structure electrode which have opening for the composition which has one opening for every picture element field for an example above were explained, you may prepare two or more openings for every picture element field. Below, the composition using the picture element electrode of the two-layer structure of having two or more openings for every picture element field is explained.
[0095] When preparing two or more openings for every picture element field, as mentioned above, it is desirable to have the configuration in which each of two or more openings has symmetry-of-revolution nature, and it is desirable that arrangement of further two or more openings has symmetry-of-revolution nature so that orientation with the liquid crystal molecule uniform in omnidirection in a picture element field may be taken. Below, the composition and operation are explained to an example for the liquid crystal display which has the picture element electrode of the two-layer structure which has arranged two or more openings so that it may have symmetry-of-revolution nature for every picture element field.
[0096] The cross-section structure of one picture element field of the liquid crystal display 400 which equipped drawing 11 with the picture element electrode 15 which has two or more opening 14a (14a1 and 14a2 are included) is shown typically. The liquid crystal display 400 has TFT substrate 400a and opposite substrate 100b (it is substantially [as opposite substrate 100b shown in drawing 1] the same.).
[0097] Drawing 11 (a) shows typically the orientation state (OFF state) of liquid crystal molecule 30a in the liquid crystal layer 30 to which voltage is not impressed. Drawing 11 (b) shows typically the state (ON initial state) where the

orientation of liquid crystal molecule 30a began to change, according to the voltage impressed to the liquid crystal layer 30. Drawing 11 (c) shows typically the state where the orientation of liquid crystal molecule 30a which changed according to the impressed voltage reached the steady state. Drawing 11 (a), (b), and (c) correspond to drawing 1 (a) about the liquid crystal display 100 equipped with the picture element electrode 15 which has one opening 14a for every picture element field, (b), and (c), respectively. In addition, the lower layer conductive layer 12 prepared in drawing 11 so that opening 14a1 and 14a2 might be countered through a dielectric layer 13 opening 14a1 and 14a2 -- respectively -- **, although the example formed so that it might lap and might exist also in opening 14a1 and the field between 14a2 (field where the upper conductive layer 14 exists) was shown Arrangement of the lower layer conductive layer 12 is not restricted to this, but it should just be arranged so that it may have the arrangement relation shown in drawing 11 (a) - (c) to opening 14a1 and each of 14a2. Moreover, since the electric field impressed to the liquid crystal layer 30 are not influenced substantially, although PATANGU especially, you may carry out patterning of the lower layer conductive layer 12 formed in the field where the conductive layer of the upper conductive layer 14 exists through a dielectric layer 13, and the position which counters.

[0098] As shown in drawing 11 (a), when the picture element electrode 15 and a counterelectrode 22 are these potentials (state where voltage is not impressed to the liquid crystal layer 30), orientation of the liquid crystal molecule 30a in a picture element field is perpendicularly carried out to the front face of both the substrates 11 and 21.

[0099] If voltage is impressed to the liquid crystal layer 30, the electric potential gradient expressed with the potential line EQ, such as having been shown in drawing 11 (b), will be formed. In the liquid crystal layer 30 located between the upper conductive layer 14 of the picture element electrode 15, and a counterelectrode 22, the uniform electric potential gradient expressed with the parallel equipotential line EQ to the front face of the upper conductive layer 14 and a counterelectrode 22 is formed. The electric potential gradient according to the potential difference of the lower layer conductive layer 12 and a counterelectrode 22 is formed in the liquid crystal layer 30 located the opening 14a1 of the upper conductive layer 14, and on 14a2. Since the electric potential gradient formed in the liquid crystal layer 30 is influenced of the voltage drop by the dielectric layer 13 at this time, the equipotential line EQ formed in the liquid crystal layer 30 falls in opening 14a1 and the field corresponding to 14a2 (two or more "valleys" is formed in the equipotential line EQ). Since the lower layer conductive layer 12 is formed in the field which counters opening 14a1 and 14a2 through a dielectric layer 13, the electric potential gradient expressed with the parallel equipotential line EQ to the field of the upper conductive layer 14 and a counterelectrode 22 is formed also in the liquid crystal layer 30 located on opening 14a1 and near [each] the center of 14a2 ("bottom of a valley" of the equipotential line EQ). In the liquid crystal layer 30 on opening 14a1 and the edge section (inside circumference of opening including the boundary (extent) of opening) EG of 14a2, the slanting electric field expressed with the potential line EQ, such as having inclined, are formed.

[0100] The torque to which orientation of the axial direction of liquid crystal molecule 30a tends to be carried out in parallel to the equipotential line EQ acts on liquid crystal molecule 30a which has a negative dielectric anisotropy. Therefore, as the arrow showed liquid crystal molecule 30a on the edge section EG in drawing 11 (b), in the right-hand side edge section EG in drawing, it carries out in the direction of a clockwise rotation, and inclines in the direction of a counterclockwise rotation in the left-hand side edge section EG in drawing, respectively (rotation), and orientation is carried out in parallel with the equipotential line EQ.

[0101] In the opening 14a1 of a liquid crystal display 400 and the edge section EG of 14a2 according to this invention as shown in drawing 11 (b) If the electric field (slanting electric field) expressed with the potential line EQ, such as having inclined to the axial direction of liquid crystal molecule 30a, occur, as shown in drawing 5 (b), liquid crystal molecule 30a inclines in the direction (the example of illustration counterclockwise rotation) with few amounts of inclinations for becoming the equipotential line EQ and parallel. Moreover, as shown in drawing 5 (c), the liquid-crystal molecule 30 a located in the field which the electric field expressed with the perpendicular equipotential line EQ to the axial direction of liquid-crystal molecule 30a generate inclines in the same direction as liquid-crystal molecule 30a located on the potential line EQ, such as having inclined, so that liquid-crystal molecule 30a and the orientation which are located on the potential line EQ, such as having inclined, may become continuously (it has consistency like).

[0102] If change of the orientation which begins from liquid crystal molecule 30a located on the potential line EQ, such as having inclined, progresses and a steady state is reached as mentioned above, as typically shown in drawing 11 (c), symmetrical inclination orientation (radial inclination orientation) will be formed about opening 14a1 and each center SA of 14a2. Moreover, inclination orientation also of the liquid crystal molecule 30a on the field of the upper conductive layer 14 located between two adjoining openings 14a1 and 14a2 is carried out so that liquid crystal molecule 30a of opening 14a1 and the edge section of 14a2 and orientation may become continuously (it has consistency like). Since liquid crystal molecule 30a on the portion located in the center of opening 14a1 and the edge

of 14a2 is influenced to the same extent of liquid crystal molecule 30a of each edge section, it maintains a perpendicular orientation state like liquid crystal molecule 30a located in opening 14a1 and the center section of 14a2. Consequently, the liquid crystal layer on the upper conductive layer 14 will also be in a radial inclination orientation state between two adjoining openings 14a1 and 14a2. However, the inclination directions of a liquid crystal molecule differ in the radial inclination direction of the liquid crystal layer between opening 14a1 and the radial inclination orientation of the liquid crystal layer in 14a2 and opening 14a1, and 14a2. If the orientation near [which is located in the center of each field which is carrying out radial inclination orientation] liquid crystal molecule 30a shown in drawing 11 (c) is observed, within opening 14a1 and 14a2, liquid crystal molecule 30a inclines between openings to liquid crystal molecule 30a inclining so that the cone which spreads toward a counterelectrode may be formed so that the cone which spreads toward the upper conductive layer 14 may be formed. In addition, since it is formed so that any radial inclination orientation may be adjusted with the inclination orientation of liquid crystal molecule 30a of the edge section, two radial inclination orientation is continuing mutually.

[0103] If voltage is impressed to the liquid crystal layer 30 as mentioned above, radial inclination orientation will be formed by beginning to incline from liquid crystal molecule 30a on two or more openings 14a1 prepared in the upper conductive layer 14, and each 14a2 edge section EG, and inclining so that liquid crystal molecule 30a of a boundary region may have consistency after that with the inclination orientation of liquid crystal molecule 30a on the edge section EG. Therefore, since the number of liquid crystal molecule 30a which answers electric field and begins to incline first increases so that there is many opening 14a formed in one picture element field, the time taken to cover the whole picture element field and to form radial inclination orientation becomes short. That is, the speed of response of a liquid crystal display is [carry out / the increase of a number, or / of opening 14a formed in a picture element electrode for every picture element field] improvable.

[0104] Thus, while the liquid crystal display which has the display grace which was excellent in the viewing-angle property in omnidirection by forming two or more openings 14a1 and 14a2 for every picture element field is realized, the response characteristic of a liquid crystal display is also improved.

[0105] Next, the relation between each configuration and relative configuration of two or more opening 14a, and the orientation of liquid crystal molecule 30a is explained, referring to drawing 12 and drawing 13 . drawing 12 -- (-- a --) -- and -- drawing 13 -- (-- a --) -- inside -- 11 -- A -- -- 11 -- A -- ' -- a line -- having met -- a cross section -- drawing 11 -- (-- a --) -- corresponding -- drawing 12 -- (-- b --) -- and -- drawing 13 -- (-- b --) -- inside -- 11 -- B -- -- 11 -- B -- ' -- a line -- having met -- a cross section -- drawing 11 -- (-- b --) --

[0106] Although drawing 12 and drawing 13 have illustrated the rectangular picture element electrode 15 (picture element field), the configuration of the appearance of the picture element electrode 15 (the upper conductive layer 14) is not restricted to this. Moreover, the liquid crystal display by this invention may have two or more electrode composition which showed the electrode composition shown in drawing 12 or drawing 13 about one picture element field to what [not only] it has only one but drawing 12 , and drawing 13 in one picture element field. Moreover, there is especially no limit, laps with the side or the angle as which a part of two or more opening 14a specifies the periphery of the upper conductive layer 14, and may be formed in the relative arrangement relation between the periphery of the picture element electrode 15 (the upper conductive layer 14), and opening 14a. This is the same also to the liquid crystal display of other operation forms in which the picture element field which has two or more opening 14a is shown. In addition, the whole picture element field is covered, and in order to stabilize orientation of a liquid crystal molecule (and improvement in a speed of response), about the desirable relative configuration between opening 14a, it mentions later.

[0107] First, the configurations of each opening 14a may be a polygon, and a round shape or an ellipse form, as explained previously. The round shape which showed the viewing-angle property in all the directions of an azimuth of a liquid crystal display 400 to regular polygons, such as a square shown in drawing 12 , and drawing 13 since it was desirable that each configuration of opening 14a had high symmetry-of-revolution nature at an improvement (rough deposit of display is abolished) sake is desirable. About the relation between the configuration of each opening 14a, and the orientation state of liquid crystal molecule 30a, since it is as previous explanation, explanation is omitted here.

[0108] Moreover, in the composition in which two or more opening 14a was formed, it is desirable that relative arrangement of two or more opening 14a has symmetry-of-revolution nature. For example, when forming four square opening 14a in the square upper conductive layer 14 as shown in drawing 12 (namely, when a picture element field is a square), it is desirable to arrange four openings 14a centering on the center SA of the square upper conductive layer 14, so that it may have symmetry-of-revolution nature. As illustrated, it is desirable to arrange so that the center SA of the square upper conductive layer 14 may serve as the axis of rotation 4 times. Thus, the field which has the radial inclination orientation formed focusing on each opening 14a when are arranged and voltage is impressed to the liquid crystal layer 30 as shown in drawing 12 (b) and (c) has symmetry-of-revolution nature 4 times centering on the center

SA of the upper conductive layer 14. Consequently, the viewing-angle property of a liquid crystal display 400 continues in the direction of an omnidirection angle, and is equalized further.

[0109] Although the drawing 12 smell illustrated the composition in which four openings 14a was formed to one picture element field, the number of opening 14a is not restricted to this. The number of opening 14a formed in one picture element field is suitably set up by size [of a picture element field], configuration, and one opening 14a in consideration of the size of the field in which radial inclination orientation is formed stably, and a speed of response. It may be unable to arrange so that the whole picture element field may be covered and it may have symmetry-of-revolution nature depending on the configuration of a picture element field, although it is desirable to cover the whole picture element field, and to arrange so that arrangement of opening 14a may have symmetry-of-revolution nature in order to improve the homogeneity of a viewing-angle property when forming much opening 14a in one picture element field. It is desirable to arrange so that latus area may be covered and it may have symmetry-of-revolution nature as much as possible. For example, when a picture element field is a rectangle, the liquid crystal display which has a sufficiently uniform viewing-angle property can be obtained by dividing a rectangle into two or more squares, and forming two or more opening 14a so that it may have symmetry-of-revolution nature to each square.

[0110] It replaces with opening 14a of the square shown in drawing 12 , and the composition which prepared circular opening 14a is shown in drawing 13 .

[0111] The viewing-angle property of a liquid crystal display is further improvable by arranging four openings 14a the same with having mentioned above, while referring to drawing 12 , so that the center SA of the upper conductive layer 14 may serve as the axis of rotation 4 times. Moreover, since the continuity of the orientation of liquid crystal molecule 30a to which the one where the configuration of opening 14a is more nearly circular met the edge section of each opening 14a rather than the polygon is high, the radial inclination orientation of liquid crystal molecule 30a is stabilized more. Furthermore, in the composition which prepares two or more opening 14a, if the configuration of opening 14a is made circular, the continuity between the radial inclination orientation formed of adjoining opening 14a will be high, and the advantage that two or more radial inclination orientation formed in a picture element field tends to be stabilized will be acquired.

[0112] For example, as shown in drawing 14 , liquid crystal molecule 30a to which circular four openings 14a is located by each center on the diagonal line of the rectangle also in the composition by which it has been arranged so that it may be located in a rectangular angle can form continuous inclination orientation. On the other hand, the orientation of liquid crystal molecule 30a in the field surrounded by four openings 14a cannot become easily continuously so that he can understand from the diagonal line of the rectangle which connects the center of opening 14a and is formed not being in agreement with the diagonal line of the square of opening 14a if four openings 14a in drawing 14 is made into a square. On the other hand, although the rectangle in which four centers of opening 14a form these four configurations of opening 14a, the rectangle which has a similarity relation, then the above-mentioned problem are solved, the continuity of the radial inclination orientation formed in each opening 14a falls. Therefore, as for the configuration of opening 14a, or arrangement, it is desirable to set up suitably in consideration of the configuration and size of a picture element field. In addition, drawing 14 shows the state where voltage was impressed to the liquid crystal layer, and the cross section which met the 11C-11C' line in drawing 14 is equivalent to drawing 11 (c).

[0113] The desirable example of arrangement of opening in the electrode composition (namely, two-layer structure electrode in which a picture element electrode or a counterelectrode has opening) which has two or more openings for every picture element field is explained still in detail.

[0114] Other patterns of the upper conductive layer 14 of other liquid crystal display 400A of the operation gestalt 1 are explained referring to drawing 15 (a). Drawing 15 (b) is the cross section which met the 15B-15B' line in drawing 15 (a), and is substantially [as drawing 11 (a)] the same except giving reference mark 14b to the solid section of the upper conductive layer 14, and giving reference mark 14b' to the unit solid section.

[0115] The upper conductive layer 14 which liquid crystal display 400A has has two or more opening 14a and solid section 14b. Opening 14a points out the portion from which the electric conduction film of the upper conductive layers 14 formed from an electric conduction film (for example, ITO film) was removed, and solid section 14b points out the portion (portions other than opening 14a) in which an electric conduction film exists. Although two or more opening 14a is formed for every picture element electrode, solid section 14b is fundamentally formed from the continuous single electric conduction film.

[0116] Two or more opening 14a is arranged so that the center may form a tetragonal lattice, and solid section (the "unit solid section" is called.) 14b' substantially surrounded by four openings 14a to which a center is located on the four lattice points which form one unit lattice has the configuration of an approximate circle form. Each opening 14a is an abbreviation star which has the side (edge) of the shape of four quadrant radii, and has the axis of rotation 4 times at

the center. In addition, in order to cover the whole picture element field and to stabilize orientation, it is desirable to form a unit lattice to the edge of the upper conductive layer 14. Therefore, as illustrated, as for the edge of the upper conductive layer 14, it is desirable that patterning is carried out to the configuration equivalent to about 1 (field corresponding to angle)/4 of about 1 (field corresponding to the side)/2 of opening 14a and opening 14a. In addition, the square (set of a tetragonal lattice) shown as the solid line in drawing 15 (a) shows the field (appearance) corresponding to the conventional picture element electrode formed from the single conductive layer.
[0117] Opening 14a located in the center section of the picture element field has the same size in the same configuration substantially. Unit solid section 14b' located in the unit lattice formed of opening 14a is an approximate circle form, and has the same size in the same configuration substantially. It connects mutually and unit solid section 14b' which adjoins mutually constitutes solid section 14b which functions as a single electric conduction film substantially.
[0118] If voltage is impressed between the upper conductive layers 14 and counterelectrodes 22 which have composition which was mentioned above, two or more liquid crystal domains where each has radial inclination orientation will be formed of the slanting electric field generated by the edge section of opening 14a. Every one liquid crystal domain is formed in the field corresponding to each opening 14a, and the field corresponding to unit solid section 14b' within a unit lattice, respectively.
[0119] Here, although the square upper conductive layer 14 is illustrated, the configuration of 14 of a picture element electrode is not restricted to this. Since the general configuration of the upper conductive layer 14 is approximated to a rectangle (a square and a rectangle are included), it can arrange opening 14a regularly in the shape of a tetragonal lattice. if opening 14a is regularly arranged so that a liquid crystal domain may be formed in all the fields in a picture element field even if the upper conductive layer 14 has configurations other than a rectangle (for example, it illustrated -- as -- the shape of a tetragonal lattice), the effect of this invention can be acquired
[0120] The configuration (configuration seen from the substrate normal) of opening 14a which the upper conductive layer 14 which liquid crystal display 400A of this operation gestalt has has, and its arrangement are explained.
[0121] The display property of a liquid crystal display originates in the orientation state (optical anisotropy) of a liquid crystal molecule, and shows an azimuth dependency. In order to reduce the azimuth dependency of a display property, it is desirable that the liquid crystal molecule is carrying out orientation by equivalent probability to all azimuths. Moreover, it is still more desirable that the liquid crystal molecule in each picture element field is carrying out orientation by equivalent probability to all azimuths. Therefore, as for opening 14a, it is desirable to have a configuration which forms a liquid crystal domain so that liquid crystal molecule 30a in each picture element field may carry out orientation by equivalent probability to all azimuths. As for the configuration of opening 14a, specifically, it is desirable to be arranged so that two or more opening 14a may have symmetry-of-revolution nature preferably [having the symmetry-of-revolution nature (preferably symmetric property more than a twofold rotation axis) which sets a symmetry axis as each center (the direction of a normal)]. Moreover, it is desirable that the configuration of unit solid section 14b' substantially surrounded by these openings also has symmetry-of-revolution nature, and it is desirable to be arranged so that unit solid section 14b' may also have symmetry-of-revolution nature.
[0122] However, as there is not necessarily no need of being arranged so that opening 14a and unit solid section 14b' may cover the whole picture element field and may have symmetry-of-revolution nature and it was shown in drawing 15 (a) For example, if a tetragonal lattice (symmetric property which has the axis of rotation 4 times) is made into a smallest unit and a picture element field is constituted by those combination, the whole picture element field can be covered and orientation of the liquid crystal molecule can be substantially carried out by equivalent probability to all azimuths.
[0123] The orientation state of liquid crystal molecule 30a when opening 14a of an abbreviation star and unit solid section 14b' of an approximate circle form which were shown in drawing 15 (a) and which have symmetry-of-revolution nature are arranged in the shape of a tetragonal lattice is explained referring to drawing 16 (a) - drawing 16 (c).
[0124] Drawing 16 (a) - (c) shows typically the orientation state of liquid crystal molecule 30a seen from the substrate normal, respectively. It is shown that the upper conductive layer 14 in which the edge has opening 14a rather than the other end prepares the edge where the point of liquid crystal molecule 30a drawn in the shape of an ellipse in drawing showing the orientation state of seen liquid crystal molecule 30a from [, such as drawing 16 (b) and (c),] the substrate normal is shown black, and liquid crystal molecule 30a inclines so that closely [a ******** substrate side]. Also in the following drawings, it is the same. Here, one unit lattice (formed of four openings 14a) in the picture element field shown in drawing 15 (a) is explained. The cross section in alignment with the diagonal line in drawing 16 (a) - drawing 16 (c) corresponds to drawing 11 (a) - drawing 11 (c), respectively, and it is explained, setting and referring to these drawings.

[0125] When the upper conductive layer 14 and a counterelectrode 22 are these potentials, in the state where voltage is not impressed to the liquid crystal layer 30, liquid crystal molecule 30a by which the direction of orientation is regulated by the perpendicular orientation layer (un-illustrating) prepared in the liquid crystal layer 30 side front face of TFT substrate 400a and opposite substrate 100b takes a perpendicular orientation state, as shown in drawing 16 (a).

[0126] If electric field are impressed to the liquid crystal layer 30, as shown in drawing 16 (b), liquid crystal molecule 30a begins to incline from the edge section of opening 14a. And surrounding liquid crystal molecule 30a also inclines so that the orientation and adjustment of liquid crystal molecule 30a toward which the edge section of opening 14a inclined may be taken, and the axial direction of liquid crystal molecule 30a is stabilized in the state where it was shown in drawing 16 (c) (radial inclination orientation).

[0127] That it is the configuration in which opening 14a has symmetry-of-revolution nature thus, liquid crystal molecule 30a in a picture element field Since liquid crystal molecule 30a inclines toward the center of opening 14a from the edge section of opening 14a at the time of voltage impression Liquid crystal molecule 30a near [where the orientation restraining force of liquid crystal molecule 30a from the edge section balances] the center of opening 14a maintains the state where orientation was perpendicularly carried out to the substrate side. The state where liquid crystal molecule 30a inclined [liquid crystal molecule 30a around it] continuously in the radial focusing on liquid crystal molecule 30a near the center of opening 14a is acquired.

[0128] Moreover, liquid crystal molecule 30a of the field corresponding to unit solid section 14b' of an approximate circle form surrounded by opening 14a of four abbreviation stars arranged in the shape of a tetragonal lattice also inclines so that it may have consistency with the orientation of liquid crystal molecule 30a which inclined by the slanting electric field generated by the edge section of opening 14a. Liquid crystal molecule 30a near [where the orientation restraining force of liquid crystal molecule 30a from the edge section balances] the center of unit solid section 14b' maintains the state where orientation was perpendicularly carried out to the substrate side, and the state where liquid crystal molecule 30a inclined [liquid crystal molecule 30a around it] continuously in the radial focusing on liquid crystal molecule 30a near the center of unit solid section 14b' is acquired.

[0129] Thus, the whole picture element field is covered, if the liquid crystal domain where liquid crystal molecule 30a takes radial inclination orientation is arranged in the shape of a tetragonal lattice, liquid crystal molecule 30a's of each axial direction existence probability will have symmetry-of-revolution nature, and the high-definition display without a rough deposit can be realized to all the viewing-angle directions. In order to reduce the viewing-angle dependency of the liquid crystal domain which has radial inclination orientation, it is desirable to have symmetry-of-revolution nature (for more than a twofold rotation axis to be desirable, and for more than the 4 times axis of rotation to be still more desirable.) with a high liquid crystal domain. Moreover, in order to reduce the viewing-angle dependency of the whole picture element field, it is desirable that two or more liquid crystal domains formed in a picture element field constitute the array (for example, tetragonal lattice) expressed with the combination of the unit (for example, unit lattice) which has high symmetry-of-revolution nature (more than a twofold rotation axis is desirable, and more than the 4 times axis of rotation is still more desirable.).

[0130] Although opening 14a has an abbreviation star, unit solid section 14b' has an approximate circle form and these showed the example arranged in the shape of a tetragonal lattice by drawing 15 (a), these arrangement is not restricted to the above-mentioned example at the configuration row of opening 14a and unit solid section 14b'.

[0131] The plan of the upper conductive layers 14A and 14B which have opening 14a of a configuration and unit solid section 14b' which are different in drawing 17 (a) and (b) is shown, respectively.

[0132] drawing 17 -- (-- a --) -- and -- (-- b --) -- respectively -- having been shown -- the upper layer -- a conductive layer -- 14 -- A -- and -- 14 -- B -- opening -- 14 -- a -- and -- a unit -- solid -- the section -- 14 -- b -- ' -- drawing 15 -- (-- a --) -- having been shown -- a picture element -- an electrode -- opening -- 14 -- a -- and -- a unit -- solid -- the section -- 14 -- b -- ' -- Opening 14a of the upper conductive layers 14A and 14B and unit solid section 14b' have the axis of rotation twice (it does not have the axis of rotation 4 times), and they are regularly arranged so that a rectangular unit lattice may be formed. Each of opening 14a has the bent star, and each unit solid section 14b' has abbreviation ellipse type (bent round shape). Even if it uses the upper conductive layers 14A and 14B, display grace can obtain the liquid crystal display excellent in the high viewing-angle property.

[0133] Furthermore, the upper conductive layers 14C and 14D as shown in drawing 18 (a) and (b), respectively can also be used.

[0134] As for the upper conductive layers 14C and 14D, opening 14a of an abbreviation cross joint is arranged in the shape of a tetragonal lattice so that unit solid section 14b' may become an abbreviation square. Of course, these may be made distorted, and you may arrange so that a rectangular unit lattice may be formed. Thus, even if it arranges regularly unit solid section 14b' of an abbreviation rectangle (a rectangle presupposes that a square and a rectangle are included.), display grace can obtain the liquid crystal display excellent in the high viewing-angle property.

[0135] However, since more nearly circular than a rectangle or an ellipse form can stabilize radial inclination orientation, the configuration of opening 14a and/or unit solid section 14b' is desirable. Since the side of opening 14a changes continuously (smoothly), this is considered for the direction of orientation of liquid crystal molecule 30a also changing continuously (smoothly).

[0136] From a viewpoint of the continuity of the direction of orientation of liquid crystal molecule 30a mentioned above, the upper conductive layers 14E and 14F shown in drawing 19 (a) and (b) are also considered. Upper conductive-layer 14E shown in drawing 19 (a) is the modification of the upper conductive layer 14 shown in drawing 15 (a), and has opening 14a which consists only of four radii. Moreover, upper conductive-layer 14F shown in drawing 19 (b) are the modification of upper conductive-layer 14D shown in drawing 18 (b), and unit solid section 14b' specified by surrounding opening 14a is formed from the combination of quadrant radii. Although each unit solid section 14b' has the axis of rotation 4 times in the opening 14a row which the upper conductive layers 14E and 14F have and it is arranged in the shape of a tetragonal lattice (it has the axis of rotation 4 times) As shown in drawing 17 (a) and (b), it may consider as the configuration which the configuration of unit solid section 14b' of opening 14a is made distorted, and has the axis of rotation twice, and you may arrange so that a rectangular grid (it has the axis of rotation twice) may be formed.

[0137] In the above-mentioned example, opening 14a of an abbreviation star or an abbreviation cross was formed, and the composition made into the abbreviation rectangle to which an approximate circle form, abbreviation ellipse type, the abbreviation square (rectangle), and the angle were able to take the configuration of unit solid section 14b' was explained. On the other hand, you may carry out negative-positive reversal of the relation between opening 14a and unit solid section 14b'. For example, upper conductive-layer 14G which have the pattern which carried out negative-positive reversal of opening 14a of the upper conductive layer 14 and unit solid section 14b' which were shown in drawing 15 (a) are shown in drawing 20 . Thus, it has the same function substantially with the upper conductive layer 14 which showed upper conductive-layer 14G which have the pattern which carried out negative-positive reversal to drawing 15 (a). In addition, like the upper conductive layers 14H and 14I shown in drawing 21 (a) and (b), respectively, when both opening 14a and unit solid section 14b' are abbreviation squares, even if it carries out negative-positive reversal, there is also a thing used as the pattern of a basis and the same pattern.

[0138] When negative-positive reversal of the pattern shown in drawing 15 (a) is carried out like the pattern shown in drawing 20 , it is desirable to form a part of opening 14a (about 1/2 or about 1/4) so that unit solid section 14b' which has symmetry-of-revolution nature may be formed in the edge section of the upper conductive layer 14. By considering as such a pattern, like the center section of the picture element field, the effect by slanting electric field is acquired and radial inclination orientation continued and stabilized to the whole picture element field can be realized also in the edge section of a picture element field.

[0139] Next, it explains any of a negative-positive pattern should be adopted as an example for upper conductive-layer 14G shown in drawing 20 which has the pattern which carried out negative-positive reversal of the pattern of the upper conductive layer 14 of drawing 15 (a), opening 14a of the upper conductive layer 14, and unit solid section 14b'.

[0140] a negative-positive -- even if it adopts which pattern, both of the patterns of the length of the side of opening 14a are the same Therefore, there is no difference by these patterns in the function to generate slanting electric field. However, the rates of surface ratio of unit solid section 14b' (ratio to the whole surface product of the upper conductive layer 14) may differ among both. That is, the area of solid section 14b (portion in which an electric conduction film actually exists) which generates the electric field adopted as the liquid crystal molecule of a liquid crystal layer may differ.

[0141] the voltage impressed to the liquid crystal domain in which the voltage impressed to the liquid crystal domain formed in opening 14a is formed in solid section 14b -- a twist -- low -- ** -- it is **, for example, if normally black mode is displayed, the liquid crystal domain formed in opening 14a will become dark That is, if the rate of surface ratio of opening 14a becomes high, it will become the inclination for display brightness to fall. Therefore, the one where the rate of surface ratio of solid section 14b is higher is desirable. In addition, although an operation of a lower layer conductive layer is disregarded and explained since it is easy, the two-layer structure electrode which the liquid crystal display by this invention has has the lower layer conductive layer (for example, lower layer conductive layer 12 of drawing 1) here to the field corresponding to opening 14a of the upper conductive layer 14. Therefore, since the electric field from a lower layer conductive layer act also on the liquid crystal layer 30 of the field corresponding to opening 14a, there are few grades to which the rate of surface ratio of opening 14a is high, and display brightness falls in connection with a bird clapper than the conventional liquid crystal display 300 explained while referring to drawing 4 (a) - (c).

[0142] It is dependent on the pitch (size) of a unit lattice in any of the pattern of drawing 15 (a) and the pattern of drawing 20 the rate of surface ratio of solid section 14b becomes high.

[0143] Drawing 22 (a) shows the unit lattice of the pattern shown in drawing 15 (a), and drawing 22 (b) shows the unit lattice (however, it centers on opening 14a.) of the pattern shown in drawing 20 . In addition, in drawing 22 (b), the portion (branch prolonged on all sides from the circular section) which has played the role which connects unit solid section 14b' in drawing 20 mutually is omitted. A length of one side of a square unit lattice (pitch) is set to p, and the length (space of one side) of the gap of opening 14a or unit solid section 14b', and a unit lattice is set to s.

[0144] The various upper conductive layers 14 from which the value of Pitch p and the single-sided space s differs were formed, and the stability of radial inclination orientation etc. was examined. Consequently, in order to generate slanting electric field required in order to acquire radial inclination orientation using the upper conductive layer 14 which has first the pattern (a "positive-type pattern" is called hereafter.) shown in drawing 22 (a), it found out that the single-sided space s was about 2.75-micrometer or more need. In order to generate the slanting electric field for acquiring radial inclination orientation about the upper conductive layer 14 which, on the other hand, has the pattern (a "negative-mold pattern" is called hereafter.) shown in drawing 22 (b), it found out that the single-sided space s was about 2.25-micrometer or more need. The rate of surface ratio of solid section 14b when changing the value of Pitch p was examined by making the single-sided space s into this lower limit, respectively. A result is shown in Table 1 and drawing 22 (c).

[Table 1]

Pitch p (micrometer) Solid aspect product ratio (%)

Positive type (a) Negative mold (b) 20 41.3 52.9 25 47.8 47.2 30 52.4 43.3 35 55.8 40.4 40 58.4 38.2 45 60.5 36.45062.2 35.0 When Pitch p is about 25 micrometers or more so that Table 1 and drawing 22 (c) may show, the rate of surface ratio of solid section 14b becomes [the direction of a positive-type (drawing 22 (a)) pattern] high. If it becomes shorter than about 25 micrometers, the rate of surface ratio of solid section 14b will become [the direction of a negative mold (drawing 22 (b))] large. Therefore, the pattern which Pitch p should adopt bordering on about 25 micrometers changes from a viewpoint of display brightness and the stability of orientation. For example, the positive-type pattern shown in drawing 22 (a) when three or less unit lattices were established crosswise [of the upper conductive layer 14 with a width of face of 75 micrometers] is desirable, and when establishing four or more unit lattices, the negative-mold pattern shown in drawing 22 (b) is desirable. What is necessary is just to choose any of a positive type or a negative mold they are so that the rate of surface ratio of solid section 14b may become large in other than the illustrated pattern.

[0145] The number of unit lattices is called for as follows. To the width of face (width or length) of the upper conductive layer 14, the size of a unit lattice is calculated, a solid aspect product ratio is calculated about each unit-lattice size, and the unit-lattice size from which a solid aspect product ratio serves as the maximum is chosen so that the unit lattice of one or two or more integer individuals may be arranged. However, in the case of a positive-type pattern, if the diameter of opening 14a is set to less than 15 micrometers when the diameters of unit solid section 14b' are less than 15 micrometers and a negative-mold pattern, the radial inclination orientation by which the orientation regulation force by slanting electric field was declined and stabilized will become is hard to be acquired. When the lower limit of these diameters is the case where the thickness of the liquid crystal layer 30 is about 3 micrometers and its thickness of the liquid crystal layer 30 is thinner than this, in addition, the diameter of unit solid section 14b' and opening 14a The lower limit of the diameter of unit solid section 14b' and opening 14a required when the thickness of the liquid crystal layer 30 is thicker than this, in order to acquire stable radial inclination orientation as it is still smaller than the above-mentioned lower limit, and to acquire stable radial inclination orientation becomes larger than the above-mentioned lower limit. Moreover, in the liquid crystal display of this invention, since the electric field by the lower layer conductive layer act, even if it enlarges the diameter of opening 14a a little from an above-mentioned result, deterioration of display grace is suppressed.

[0146] Except the picture element electrode 15 being a two-layer structure electrode which has opening, the composition of the liquid crystal display of this operation form 1 mentioned above can adopt the same composition as a well-known perpendicular orientation type liquid crystal display, and can manufacture it by the well-known manufacture method. Here, the formation method of the picture element electrode of two-layer structure is explained, and others omit. Drawing 1 (a) is referred to again here.

[0147] The deposition process of the lower layer conductive layer 12 and the becoming transparent conductive layer (typically ITO layer) can be carried out by the well-known manufacture method. In the process of the conventional liquid crystal display, patterning of this conductive layer is carried out to a predetermined configuration, and let it be a picture element electrode. In the patterning process of the picture element electrode in the manufacture process of the conventional liquid crystal display, patterning of the lower layer conductive layer 12 of the liquid crystal display of this operation form can be carried out. The pattern of a lower layer conductive layer may be the same as a picture element electrode, and is good also as a pattern divided so that it might correspond to opening 14a formed in the upper

conductive layer 14. The lower layer conductive layer 12 is connected to the drain electrode of TFT as well as the conventional picture element electrode etc. electrically (it is [a drain and] the electrode of this potential substantially).
[0148] It continues all over the simultaneously of the front face of substrate 100a which carried out patterning of the lower layer conductive layer 12, and a dielectric layer 13 is formed. A dielectric layer 13 can be formed using a transparent photopolymer, for example. A conductive layer is again deposited on a dielectric layer 13. By carrying out patterning of the obtained conductive layer, the upper conductive layer 14 which has opening 14a is formed.
[0149] In addition, the contact hole for connecting the upper conductive layer 14 to the drain electrode of TFT is beforehand formed in the dielectric layer 13. This process can also be performed in a well-known process. What is necessary is just to connect the upper conductive layer 14 and the lower layer conductive layer 12 to the same TFT, as illustrated, if the composition which makes the upper conductive layer 14 and the lower layer conductive layer 12 drive with this potential is adopted. Moreover, when this composition is adopted, there is also an advantage that the conventional drive circuit can be used as it is.
[0150] In addition, in order to carry out perpendicular orientation of the liquid crystal molecule which has a negative dielectric anisotropy typically, the perpendicular orientation layer (un-illustrating) is formed in the liquid crystal layer 30 side front face of the picture element electrode 15 and a counterelectrode 22. A perpendicular orientation layer is formed in the viewing area of substrate 100a of printing, after the upper conductive layer 14 which has opening 14a is formed.
[0151] The nematic-liquid-crystal material which has a negative dielectric anisotropy as a liquid crystal material is used. Moreover, the liquid crystal display in guest-host mode can also be obtained by adding dichroic coloring matter into the nematic-liquid-crystal material which has a negative dielectric anisotropy. The liquid crystal display in guest-host mode does not need a polarizing plate.
[0152] (Operation gestalt 2) The structure of one picture element field of liquid crystal display 400B of the operation gestalt 2 by this invention is explained, referring to drawing 23 (a) and (b). Moreover, in the following drawings, the same reference mark shows the component of the liquid crystal display 400 shown in drawing 11 , and the component which has the same function substantially, and the explanation is omitted. Drawing 23 (a) is the plan seen from the substrate normal, and drawing 23 (b) is equivalent to the cross section which met the 23B-23B' line in drawing 23 (a). Drawing 23 (b) shows typically the state where voltage is not impressed to a liquid crystal layer.
[0153] As shown in drawing 23 (a) and (b), liquid crystal display 400B differs from liquid crystal display 400A of the operation gestalt 1 shown in drawing 15 (a) and (b) in the point that TFT substrate 400b has heights 40 inside opening 14a of the upper conductive layer 14. The perpendicular orientation film (un-illustrating) is prepared in the front face of heights 40. Hereafter, the TFT substrate which has heights 40 inside opening 14a will be shown by reference mark 400b regardless of the structure of heights 40.
[0154] In addition, although liquid crystal display 400B which formed heights 40 in opening 14a of the upper conductive layer 14 of the liquid crystal display 400 shown in drawing 11 is illustrated, it is applicable to other liquid crystal displays of the operation gestalt 1 here.
[0155] As shown in drawing 23 (a), the cross-section configuration of the field inboard of the substrate 11 of heights 40 is the same as the configuration of opening 14a, and is an abbreviation star here. However, the adjoining heights 40 are connected mutually, and they are formed so that unit solid section 14b' may be completely surrounded to an approximate circle form. The cross-section configuration of field inboard perpendicular to the substrate 11 of these heights 40 is a trapezoid as shown in drawing 23 (b). That is, it has 40s of sides which inclined on the taper square theta (<90 degree) to 40t of top faces parallel to a substrate side, and the substrate side. Since the perpendicular orientation film (un-illustrating) is formed so that heights 40 may be covered, to liquid crystal molecule 30a of the liquid crystal layer 30, 40s of sides of heights 40 will have the orientation restraining force of the same direction as the orientation regulation direction by slanting electric field, and they act so that radial inclination orientation may be stabilized.
[0156] An operation of these heights 40 is explained referring to drawing 24 (a) - (d), drawing 25 (a), and (b).
[0157] First, the relation between the orientation of liquid crystal molecule 30a and the surface configuration of having a perpendicular stacking tendency is explained, referring to drawing 24 (a) - (d).
[0158] As shown in drawing 24 (a), orientation of the liquid crystal molecule 30a on a level front face is perpendicularly carried out to a front face by the surface (typically front face of a perpendicular orientation film) orientation restraining force which has a perpendicular stacking tendency. Thus, if the electric field expressed with the perpendicular equipotential line EQ to liquid crystal molecule 30a in a perpendicular orientation state to the axial direction of liquid crystal molecule 30a are impressed, it will act on liquid crystal molecule 30a by the probability that the torque which makes it incline in a clockwise rotation or the direction of a counterclockwise rotation is equal. Therefore, in the parallel monotonous liquid crystal layer 30 in inter-electrode [of type arrangement] which counters

mutually, liquid crystal molecule 30a which receives the torque of the direction of a clockwise rotation, and liquid crystal molecule 30a which receives the torque of a direction in a counterclockwise rotation are intermingled. Consequently, change in the orientation state according to the voltage impressed to the liquid crystal layer 30 may not take place smoothly.

[0159] If the electric field expressed with the level equipotential line EQ are impressed to liquid crystal molecule 30a which is carrying out orientation perpendicularly to the sloping front face as shown in drawing 24 (b), liquid crystal molecule 30a inclines in the direction (the example of illustration clockwise rotation) with few amounts of inclinations for becoming the equipotential line EQ and parallel. Moreover, as shown in drawing 24 (c), liquid crystal molecule 30a which is carrying out orientation perpendicularly to the level front face inclines in the same direction (clockwise rotation) as liquid crystal molecule 30a located on the sloping front face so that liquid crystal molecule 30a and orientation which are carrying out orientation perpendicularly to the sloping front face may become continuously (it has consistency like). [0160] As shown in drawing 24 (d), liquid crystal molecule 30a on a top face and a base carries out orientation so that it may have consistency with the direction of orientation where a cross section is regulated to the irregularity-like front face where the trapezoid continued by liquid crystal molecule 30a on each sloping front face.

[0161] The liquid crystal display of this operation gestalt stabilizes radial inclination orientation by making in agreement the direction of the orientation restraining force by the configuration (heights) of such a front face, and the orientation regulation direction by slanting electric field.

[0162] Drawing 25 (a) and (b) show the state where voltage was impressed to the liquid crystal layer 30 shown in drawing 23 (b), respectively. drawing 25 (a) According to the voltage impressed to the liquid crystal layer 30, the state (ON initial state) where the orientation of liquid crystal molecule 30a began to change is shown typically, and drawing 25 (b) shows typically the state where the orientation of liquid crystal molecule 30a which changed according to the impressed voltage reached the steady state. The curve EQ in drawing 25 (a) and (b) shows the equipotential line EQ.

[0163] When the upper conductive layer 14 and the lower layer conductive layer 12, and a counterelectrode 22 are these potentials (state where voltage is not impressed to the liquid crystal layer 30), as shown in drawing 23 (b), orientation of the liquid crystal molecule 30a in a picture element field is perpendicularly carried out to the front face of both the substrates 11 and 21. At this time, orientation of the liquid crystal molecule 30a which touches the perpendicular orientation film (un-illustrating) of 40s of sides of heights 40 is perpendicularly carried out to 40s of sides, and liquid crystal molecule 30a near the 40s of the sides takes the inclined orientation, as the interaction (elasticity property as a continuum) with surrounding liquid crystal molecule 30a illustrated.

[0164] If voltage is impressed to the liquid crystal layer 30, the electric potential gradient expressed with the potential line EQ, such as having been shown in drawing 25 (a), will be formed. Within the liquid crystal layer 30 located between solid section 14b of the upper conductive layer 14, and a counterelectrode 22, this equipotential line EQ To the front face of solid section 14b and a counterelectrode 22, it is parallel and falls in the field corresponding to opening 14a of the upper conductive layer 14. In the liquid crystal layer 30 on the edge section (inside circumference of opening 14a including the boundary (extent) of opening 14a) EG of opening 14a, the slanting electric field expressed with the potential line EQ, such as having inclined, are formed. Moreover, the electric field expressed with the liquid crystal layer 30 of the field which is not influenced of the potential of the upper conductive layer 14 by the lower layer conductive layer 12 and the equipotential line EQ parallel to the front face of a counterelectrode 22 are generated in the field corresponding to opening 14a of the upper conductive layer 14.

[0165] As were mentioned above by this slanting electric field and the arrow showed liquid crystal molecule 30a on the edge section EG in drawing 25 (a), in the right-hand side edge section EG in drawing, it carries out in the direction of a clockwise rotation, and inclines in the direction of a counterclockwise rotation in the left-hand side edge section EG in drawing, respectively (rotation), and orientation is carried out in parallel with the equipotential line EQ. The orientation regulation direction by this slanting electric field is the same as the orientation regulation direction by 40s of sides in which it is located in each edge section EG.

[0166] If change of the orientation which begins from liquid crystal molecule 30a located on the potential line EQ, such as having inclined, progresses and a steady state is reached as mentioned above, it will be in the orientation state typically shown in drawing 25 (b). Liquid crystal molecule 30a located near the center of opening 14a (i.e., near the center of 40t of top faces of heights 40) Since it is influenced almost equally of the orientation of liquid crystal molecule 30a of the edge section EG of the both sides which counter mutually [opening 14a] Liquid crystal molecule 30a of a field which maintained the perpendicular orientation state to the equipotential line EQ, and is distant from the center of opening 14a (40t of top faces of heights 40) It inclines in response to the influence of the orientation of liquid crystal molecule 30a of the edge section EG of the respectively nearer one, and symmetrical inclination orientation is formed about the center SA of opening 14a (40t of top faces of heights 40). Moreover, also in the field corresponding to unit solid section 14b' surrounded substantially, symmetrical inclination orientation is formed about the center SA of

unit solid section 14b' by opening 14a and heights 40.
[0167] Thus, also in liquid crystal display 400B of the operation gestalt 2, the liquid crystal domain which has radial inclination orientation is formed like liquid crystal display 400A of the operation gestalt 1 corresponding to opening 14a and unit solid section 14b' (refer to drawing 16 (c)). Since heights 40 are formed so that unit solid section 14b' may be completely surrounded to an approximate circle form, a liquid crystal domain is formed corresponding to the field of an approximate circle form surrounded by heights 40. Furthermore, since the side of heights 40 established inside opening 14a acts so that liquid crystal molecule 30a near edge section EG of opening 14a may be made to incline in the same direction as the direction of orientation by slanting electric field, it stabilizes radial inclination orientation.
[0168] It acts on slanting electric field with the orientation regulation force being natural only at the time of voltage impression, but the strength is dependent on it at field strength (size of applied voltage). therefore, field strength -- being weak (that is, applied voltage being low) -- when the orientation regulation force by slanting electric field is weak and external force joins a liquid crystal panel, radial inclination orientation may collapse by flow of liquid crystal material Unless only the voltage which will once generate the slanting electric field which demonstrate the orientation regulation force strong enough if radial inclination orientation collapses is impressed, radial inclination orientation is not restored. On the other hand, the orientation regulation force by 40s of sides of heights 40 is very strong as it acts regardless of applied voltage and is known as an achoring effect of an orientation film. Therefore, even if a flow of liquid crystal material arises and radial inclination orientation once collapses, liquid crystal molecule 30a near the 40s of the sides of heights 40 is maintaining the same direction of orientation as the time of radial inclination orientation. Therefore, if a flow of liquid crystal material carries out even a stop, radial inclination orientation will be restored easily.
[0169] Thus, in addition to the feature which liquid crystal display 400A of the operation gestalt 1 has, liquid crystal display 400B of the operation gestalt 2 has the feature of being strong, to external force. Therefore, liquid crystal display 400B is used suitable for PC and PDA with many opportunities to which external force is easy to be impressed and which are carried and used.
[0170] In addition, the advantage that its rate of contribution to the display of the liquid crystal domain formed corresponding to opening 14a will improve if heights 40 are formed using the high dielectric of transparency is acquired. On the other hand, if heights 40 are formed using an opaque dielectric, the advantage that the optical leakage resulting from the retardation of liquid crystal molecule 30a which is carrying out inclination orientation by 340s of sides of heights 40 can be prevented will be acquired. The use of a liquid crystal display etc. responds and any are adopted should just determine. When a photopolymer is used in any case, there is an advantage which can simplify the process which carries out patterning corresponding to opening 14a. In order to obtain sufficient orientation restraining force, when the thickness of the liquid crystal layer 30 is about 3 micrometers, as for the height of heights 40, it is desirable that it is in the range which is about 0.5 micrometers - about 2 micrometers. Generally, as for the height of heights 40, it is desirable that it is within the limits of about 1 of thickness of liquid crystal layer 30/6 - abbreviation 2/3.
[0171] As mentioned above, liquid crystal display 400B has heights 40 inside opening 14a of the upper conductive layer 14, and 40s of sides of heights 40 has the orientation restraining force of the same direction as the orientation regulation direction by slanting electric field to liquid crystal molecule 30a of the liquid crystal layer 30. The desirable conditions for having the orientation restraining force of the direction as the orientation regulation direction by slanting electric field where 40s of sides is the same are explained referring to drawing 26 (a) - (c).
[0172] Drawing 26 (a) - (c) shows typically the cross section of liquid crystal displays 400C, 400D, and 400E, respectively, and is equivalent to drawing 25 (a). liquid crystal displays 400C, 400D, and 400E -- each -- opening 14a -- although it has heights inside at least, the arrangement relation between the heights 40 whole as the one structure and opening 14a differs from liquid crystal display 400B
[0173] In liquid crystal display 400B mentioned above, as shown in drawing 25 (a), the whole heights 40 as the structure are formed inside opening 14a, and the base of heights 40 is smaller than opening 14a. In liquid crystal display 400C shown in drawing 26 (a), in liquid crystal display 400D shown in drawing 26 (b), the base of heights 40A is in agreement with opening 14a, and heights 40B has a larger base than opening 14a, and it is formed so that surrounding solid section (electric conduction film) 14b of opening 14a may be covered. Solid section 14b is not formed on 40s of which [of these heights 40, 40A, and 40B] sides. Consequently, as shown in each drawing, on solid section 14b, the equipotential line EQ is almost flat and falls in opening 14a as it is. Therefore, 40s of sides of the heights 40A and 40B of liquid crystal displays 400C and 400D demonstrates the orientation restraining force of the same direction as the orientation restraining force by slanting electric field like the heights 40 of liquid crystal display 400B mentioned above, and they stabilize radial inclination orientation.
[0174] On the other hand, the base of heights 40C of liquid crystal display 400E shown in drawing 26 (c) is larger than

opening 14a, and surrounding solid section 14b of opening 14a is formed on 40s of sides of heights 40C. It is the influence of solid section 14b formed on 40s of this side, and a mountain is formed in the equipotential line EQ. It has the inclination opposite to the potential line EQ -- the mountain of the equipotential line EQ falls in opening 14a -- and it is shown that the slanting electric field to which this carries out radial inclination orientation of the liquid crystal molecule 30a are generating the slanting electric field of a retrose. Therefore, in order to have the orientation restraining force of the direction as the orientation regulation direction by slanting electric field where 40s of sides is the same, it is desirable that solid section (electric conduction film) 14b is not formed on 40s of sides.
[0175] Next, the cross-section structure which met the 27A-27A' line of heights 40 shown in drawing 23 (a) is explained, referring to drawing 27 .
[0176] having mentioned above -- as -- drawing 23 -- (-- a --) -- having been shown -- heights -- 40 -- a unit -- solid -- the section -- 14 -- b -- ' -- an approximate circle -- type -- perfect -- surrounding -- as -- forming -- having -- **** -- since -- adjoining -- a unit -- solid -- the section -- 14 -- b -- ' -- mutual -- connecting -- a role -- achieving -- **** -- a portion (branch prolonged on all sides from the circular section) -- drawing 27 -- having been shown -- Therefore, in the process which deposits the electric conduction film which forms solid section 14b of the upper conductive layer 14, the danger that an open circuit will arise on heights 40, or ablation will arise at the back process of a manufacture process is high.
[0177] Then, like liquid crystal display 400F shown in drawing 28 (a) and (b), if it forms so that heights 40D which became independent in opening 14a, respectively may be contained completely, since it is formed in the flat front face of a substrate 11, the danger of the electric conduction film which forms solid section 14b that an open circuit and ablation will take place will disappear. in addition, heights 40D surrounds unit solid section 14b' completely to an approximate circle form -- as -- although not formed, the liquid crystal domain of an approximate circle form corresponding to unit solid section 14b' is formed, and the radial inclination orientation is stabilized like a previous example
[0178] by forming heights 40 in opening 14a, the effect of stabilizing radial inclination orientation was not restricted to opening 14a of the illustrated pattern, but the operation form 1 explained it -- it can apply similarly to opening 14a of all patterns, and the same effect can be acquired In addition, in order to fully demonstrate the orientation stabilization effect to the external force by heights 40, as for the pattern (it is a pattern when it sees from a substrate normal) of heights 40, it is desirable that it is the configuration which surrounds the liquid crystal layer 30 of the largest possible field. The orientation stabilization effect according [the direction of the positive-type pattern which has circular unit solid section 14b'] to heights 40 is larger than the negative-mold pattern which follows, for example, has circular opening 14a.
[0179] (Operation form 3) In the liquid crystal display of the above-mentioned operation form 1 By countering mutually through the liquid crystal layer 30, using as a two-layer structure electrode one electrode of the picture element electrodes 15 and counterelectrodes 22 which specify a picture element field (the case of the picture element electrode 15 having been illustrated), and preparing opening 14a in the upper conductive layer 14 Slanting electric field were made to generate at the time of voltage impression, and radial inclination orientation of the liquid crystal molecule was carried out using this slanting electric field. The liquid crystal display of the operation form 2 stabilized radial inclination orientation by preparing heights in opening 14a of the upper conductive layer 14.
[0180] This operation form 3 explains the liquid crystal display which equips with the further orientation regulation structure a different substrate (the above-mentioned example opposite substrate) from the substrate (the above-mentioned example TFT substrate) in which the two-layer structure electrode was formed. In the following explanation, the electrode structure where the slanting electric field mentioned above realize radial inclination orientation will be called 1st orientation regulation structure, and the further orientation regulation structure prepared in a different side from the 1st orientation regulation structure to a liquid crystal layer will be called 2nd orientation regulation structure.
[0181] Next, the concrete structure and a concrete operation of the 2nd orientation regulation structure are explained. The case where the 1st orientation regulation structure is prepared in a TFT substrate, and the 2nd orientation regulation structure is prepared in the opposite substrate along with old explanation is explained.
[0182] Drawing 29 (a) Opposite substrate 200b which has the 2nd orientation regulation structure 28 in - (e) is shown typically. A reference mark common to the same component is substantially attached with an above-mentioned liquid crystal display, and the explanation is omitted here.
[0183] Drawing 29 (a) The 2nd orientation regulation structure 28 shown in - (e) acts so that radial inclination orientation of the liquid crystal molecule 30a of the liquid crystal layer 30 may be carried out. However, the directions which make liquid crystal molecule 30a incline differ with the orientation regulation structure 28 shown in the orientation regulation structure 28 shown in drawing 29 (a) - (d), and drawing 29 (e).

[0184] Drawing 29 (a) The inclination direction of the liquid crystal molecule by the 2nd orientation regulation structure 28 shown in - (d) is adjusted with the direction of orientation of the radial inclination orientation of the liquid crystal domain formed in the field corresponding to unit solid section 14b' (for example, refer to drawing 11 (c)) of the upper conductive layer 14 of the 1st orientation regulation structure. On the other hand, the inclination direction of the liquid crystal molecule by the 2nd orientation regulation structure 28 shown in drawing 29 (e) is adjusted with the direction of orientation of the radial inclination orientation of the liquid crystal domain formed in the field corresponding to opening 14a (for example, refer to drawing 11 (c)) of the upper conductive layer 14 of the 1st orientation regulation structure.

[0185] The 2nd orientation regulation structure 28 shown in drawing 29 (a) is constituted by opening 22a of a counterelectrode 22 prepared in the position which counters the upper conductive layer 14 (for example, unit solid section 14b' of drawing 15 (a)). In addition, the perpendicular orientation film (un-illustrating) is prepared in the front face by the side of the liquid crystal layer 30 of opposite substrate 200b.

[0186] This 2nd orientation regulation structure 28 discovers the orientation regulation force as well as the above-mentioned 1st orientation regulation structure only at the time of voltage impression. Since the 2nd orientation regulation structure 28 should just act the orientation regulation force to the liquid crystal molecule in the liquid crystal domain which takes the radial inclination orientation formed of the 1st orientation regulation structure, the size of opening 22a is smaller than opening 14a prepared in the upper conductive layer 14, and it is smaller than unit solid section 14b' (for example, refer to drawing 15 (a)) surrounded by opening 14a. [of a size] For example, effect sufficient in below the half of the area of opening 14a or unit solid section 14b' can be acquired. By preparing opening 22a of a counterelectrode 22 in the position which counters the center section of unit solid section 14b' of the upper conductive layer 14, the continuity of the orientation of a liquid crystal molecule becomes high, and the position of the medial axis of radial inclination orientation can be fixed.

[0187] Thus, when the structure which discovers orientation restraining force was adopted as 2nd orientation regulation structure only at the time of voltage impression and normally black mode is adopted since almost all liquid crystal molecule 30a of the liquid crystal layer 30 took the perpendicular orientation state in the voltage state where it does not impress, a black display state sets, and optical leakage hardly occurs but can realize the display of a good contrast ratio.

[0188] However, an after-image may be checked by looking, when radial inclination orientation is not formed since orientation restraining force does not occur in the voltage state where it does not impress, and not much big stress is impressed to a liquid crystal panel, since orientation restraining force is [applied voltage] small at the time of a low.

[0189] Drawing 29 (b) Since the 2nd orientation regulation structure 28 shown in - (d) is not concerned with no impression impressing [of voltage] but discovers orientation restraining force, the radial inclination orientation stabilized in all display gradation is acquired, and it is excellent also in the resistance over stress.

[0190] First, the 2nd orientation regulation structure 28 shown in drawing 29 (b) has heights 22b which projected on the counterelectrode 22 at the liquid crystal layer 30 side. Although there is especially no limit in the material which forms heights 22b, it can form easily using dielectric materials, such as a resin. In addition, the perpendicular orientation film (un-illustrating) is prepared in the front face by the side of the liquid crystal layer 30 of opposite substrate 200b. Heights 22b carries out inclination orientation of the liquid crystal molecule 30a to a radial by the size effect of the front face (it has a perpendicular stacking tendency). moreover, a gently-sloping hill when the resin material which deforms with heat was used, as shown in drawing 29 (b) with heat treatment after patterning -- since heights 22b which has the upper cross-section configuration can be formed easily, it is desirable As illustrated, the heights which have the configuration of the shape of heights 22b which has the gently-sloping cross-section configuration (for example, some spheres) which has a vertex, or a cone are excellent in the effect which fixes the center position of radial inclination orientation.

[0191] The 2nd orientation regulation structure 28 shown in drawing 29 (c) is constituted by the level stacking-tendency front face by the side of the liquid crystal layer 30 in opening (crevice is sufficient) 23a prepared in the dielectric layer 23 formed in the bottom of a counterelectrode 22 (substrate 21 side). Here, the front face in opening 23a is used as the level stacking-tendency front face by not forming the perpendicular orientation film 24 formed in the liquid crystal layer 30 side of opposite substrate 200b only in opening 23a. It may replace with this, and as shown in drawing 29 (d), you may form the level orientation film 25 only in opening 23a.

[0192] once forming the perpendicular orientation film 24 all over opposite substrate 200b, and the level orientation film shown in drawing 29 (d) irradiating ultraviolet rays alternatively at the perpendicular orientation film 24 which exists in opening 23a, and reducing a perpendicular stacking tendency -- you may form A level stacking tendency required since the 2nd orientation regulation structure 28 is constituted does not need to have so small a pre tilt angle as the orientation film used for TN liquid crystal display, for example, a pre tilt angle should just be 45 degrees or less.

[0193] On the level stacking-tendency front face in opening 23a, as shown in drawing 29 (c) and (d), since liquid crystal molecule 30a tends to carry out orientation horizontally to a substrate side, the orientation of liquid crystal molecule 30a which is carrying out perpendicular orientation of [on the surrounding perpendicular orientation film 24], and orientation which maintains a continuity are formed, and radial inclination orientation which was illustrated is acquired.

[0194] Preparing alternatively level stacking-tendency front faces (a front face or a level orientation film of an electrode etc.) on the flat front face of a counterelectrode 22, without establishing a crevice (formed of opening of a dielectric layer 23) in the front face of a counterelectrode 22 can also stabilize radial inclination orientation further by the size effect of a crevice, although radial inclination orientation is acquired.

[0195] In order to form a crevice in the front face by the side of the liquid crystal layer 30 of opposite substrate 200b, if the overcoat layer of a light-filter layer or a light-filter layer is used, since a process will not increase, it is desirable as a dielectric layer 23. Moreover, since the field where voltage is impressed to the liquid crystal layer 30 through heights 22b does not exist like the structure shown in drawing 29 (a), the structure shown in drawing 29 (c) and (d) has little decline in the use efficiency of light.

[0196] Like the 2nd orientation regulation structure 28 shown in drawing 29 (d), using opening 23a of a dielectric layer 23, the 2nd orientation regulation structure 28 shown in drawing 29 (e) forms a crevice in the liquid crystal layer 30 side of opposite substrate 200b, and forms the level orientation film 26 only in the bottom of the crevice. Instead of forming the level orientation film 26, as shown in drawing 29 (c), you may expose the front face of a counterelectrode 22.

[0197] the [the 1st orientation regulation structure mentioned above and] -- liquid crystal display 400G [equipped with 2 orientation regulation structures] are shown in drawing 30 (a) and (b) Drawing 30 (a) is a plan and drawing 30 (b) is equivalent to the cross section which met the 22B-22B' line in drawing 30 (a).

[0198] Liquid crystal display 400G have TFT substrate 400a which has the upper conductive layer 14 which has opening 14a which constitutes the 1st orientation regulation structure, and opposite substrate 200b which has the 2nd orientation regulation structure 28. In addition, the 1st orientation regulation structure is not restricted to the composition illustrated here, but the various composition mentioned above can be suitably used for it. Moreover, although what discovers the orientation regulation force also at the time of no voltage impressing (drawing 29 (b) - (d) and drawing 29 (e)) is illustrated as 2nd orientation regulation structure 28, it can replace with the 1st orientation regulation structure shown in drawing 29 (b) - (d), and what was shown in drawing 29 (a) can also be used.

[0199] The inside of the 2nd orientation regulation structure 28 prepared in opposite substrate 200b of liquid crystal display 400G, The 2nd orientation regulation structure 28 established near the center of the field which counters solid section 14b of the upper conductive layer 14 Drawing 29 (b) Although shown in - (d), it is either, and the 2nd orientation regulation structure 28 established near the center of the field which counters opening 14a of the upper conductive layer 14 is shown in drawing 29 (e).

[0200] Thus, by arranging, the direction of the radial inclination orientation formed of the 1st orientation regulation structure in the state which impressed voltage to the liquid crystal layer 30, i.e., the state where voltage was impressed between the upper conductive layer 14 and the counterelectrode 22, and the direction of the radial inclination orientation formed of the 2nd orientation regulation structure 28 have consistency, and radial inclination orientation is stable. This situation is typically shown in drawing 30 (a) - (c). Drawing 30 (a) shows the time of no voltage impressing, drawing 30 (b) shows the state (ON initial state) where orientation began to change after voltage impression, and drawing 30 (c) shows the steady state under voltage impression typically.

[0201] As shown in drawing 31 (a), also in voltage the state where it does not impress, the orientation regulation force by the 2nd orientation regulation structure (drawing 29 (b) - (d)) acts on nearby liquid crystal molecule 30a, and forms radial inclination orientation.

[0202] If it begins to impress voltage, the electric field shown by the equipotential line [like] EQ shown in drawing 31 (b) will occur (based on the 1st orientation regulation structure), the liquid crystal domain liquid crystal molecule 30a carried out [the domain] radial inclination orientation will be formed in the field corresponding to opening 14a and solid section 14b, and a steady state as shown in drawing 31 (c) will be reached. At this time, the inclination direction of liquid crystal molecule 30a in each liquid crystal domain is in agreement with the inclination direction of liquid crystal molecule 30a by the orientation regulation force of the 2nd orientation regulation structure 28 prepared in the corresponding field.

[0203] if stress is impressed to liquid crystal display 400G in a steady state, although the radial inclination orientation of the liquid crystal layer 30 will once collapse, if stress is removed -- the [the 1st orientation regulation structure and] -- since the orientation regulation force by 2 orientation regulation structures is acting on liquid crystal molecule 30a, it returns to a radial inclination orientation state Therefore, generating of the after-image by stress is suppressed.

Although there is a possibility of the retardation by radial inclination orientation occurring and falling the contrast ratio of a display also at the time of no voltage impressing when the orientation regulation force by the 2nd orientation regulation structure 28 is too strong Since the orientation regulation force by the 2nd orientation regulation structure 28 should just have the effect which fixes the stabilization and the medial-axis position of radial inclination orientation which are formed of the 1st orientation regulation structure The strong orientation regulation force is unnecessary and the orientation regulation force of a grade in which a retardation to the extent that display grace is reduced is not generated is enough as it.
[0204] For example, when adopting heights 22b shown in drawing 29 (b), height (thickness) will be stopped by about 15 micrometers by the level in which sufficient orientation regulation force is acquired and the fall of the contrast ratio by the retardation does not have a problem practically, either, respectively, if a diameter forms heights 22b which is about 1 micrometer to unit solid section 14b' whose diameter is about 30 micrometers - about 35 micrometers.
[0205] drawing 32 (a) and (b) -- the [the 1st orientation regulation structure and] -- other liquid crystal display 400H [equipped with 2 orientation regulation structures] are shown It is the cross section with which drawing 32 (a) met the plan and drawing 32 (b) met the 32B-32B' line of drawing 32 (a).
[0206] Liquid crystal display 400H do not have the 2nd orientation regulation structure in the field which counters opening 14a of the upper conductive layer 14 of TFT substrate 400a. Since it is accompanied by the difficulty on a process, as for forming the 2nd orientation regulation structure 28 shown in drawing 29 (e) which should be formed in the field which counters opening 14a, it is desirable to use only either of the 2nd orientation regulation structures 28 shown in drawing 29 (a) - (d) from a viewpoint of productivity. Since especially the 2nd orientation regulation structure 28 shown in drawing 29 (b) can be manufactured in a simple process, it is desirable.
[0207] Even if it did not prepare the 2nd orientation regulation structure in the field corresponding to opening 14a, as it was typically shown in drawing 33 (a) - (c) like liquid crystal display 400H, the same radial inclination orientation as liquid crystal display 400G is acquired, and the stress-proof nature is also satisfactory practically.
(Operation form 4) The dielectric layer by which the liquid crystal display of this operation form was formed between the upper conductive layer of a picture element electrode and the lower layer conductive layer has a hole (hole) or a crevice in opening of the upper conductive layer. That is, the picture element electrode of the two-layer structure of the liquid crystal display of this operation form has the structure (the crevice was formed) where the structure (the hole was formed) where all of the dielectric layers located in opening of the upper conductive layer were removed, or the part was removed.
[0208] First, the structure of a liquid crystal display 500 and operation equipped with the picture element electrode by which the hole was formed in the dielectric layer are explained, referring to drawing 34 .
[0209] The upper conductive layer 14 of the picture element electrode 15 has opening 13a formed corresponding to opening 14a which the upper conductive layer 14 has [the dielectric layer 13 prepared between the lower layer conductive layer 12 and the upper conductive layer 14] while having opening 14a, and, as for the liquid crystal display 500, the lower layer conductive layer 12 is exposed in opening 13a. Generally the side attachment wall of opening 13a of a dielectric layer 13 is formed in the shape of a taper (taper angle : theta). As for a liquid crystal display 500, a dielectric layer 13 acts like the picture element electrode 15 of a liquid crystal display 100 substantially by having the same structure substantially with the liquid crystal display 100 of the operation gestalt 1 except for having opening 13a, and the picture element electrode 15 of two-layer structure makes the liquid crystal layer 30 a radial inclination orientation state at the time of voltage impression.
[0210] Operation of a liquid crystal display 500 is explained referring to drawing 34 (a) - (c). Drawing 34 (a) - (c) corresponds to drawing 1 [about the liquid crystal display 100 of the operation gestalt 1] (a) - (c), respectively.
[0211] As shown in drawing 34 (a), at the time (OFF state) of no voltage impressing, orientation of the liquid crystal molecule 30a in a picture element field is perpendicularly carried out to the front face of both the substrates 11 and 21. Here, the orientation restraining force by the side attachment wall of opening 13a ignores and explains for simplicity.
[0212] If voltage is impressed to the liquid crystal layer 30, the electric potential gradient expressed with the potential line EQ, such as having been shown in drawing 34 (b), will be formed. Inclination electric field are formed like the electric potential gradient shown also in the liquid crystal layer 30 of a liquid crystal display 500 at drawing 1 (b) so that what the equipotential line EQ has fallen in the field corresponding to opening 14a of the upper conductive layer 14 (the "valley" is formed.) may show. However, since the dielectric layer 13 of the picture element electrode 15 has opening 13a to the field corresponding to opening 14a of the upper conductive layer 14, the voltage impressed to the liquid crystal layer 30 of a field [in opening 14a (inside of opening 13a)] is the potential difference of the lower layer conductive layer 12 and a counterelectrode 22 itself, and the voltage drop (capacitive component rate) by the dielectric layer 13 does not generate it. That is, the seven equipotential lines illustrated between the upper conductive layer 14 and the counterelectrode 22 cover the liquid crystal layer 30 whole, it is seven (as opposed to one of the five

equipotential lines EQ having invaded into a dielectric layer 13 in drawing 1 (b)), and the whole picture element field is covered and fixed voltage is impressed.
[0213] Thus, by forming opening 13a in a dielectric layer 13, the same voltage as the liquid crystal layer 30 corresponding to other fields is impressed, and the thing of it can be carried out also to the liquid crystal layer 30 corresponding to opening 13a. However, since the thickness of the liquid crystal layer 30 to which voltage is impressed changes with places in a picture element field, change of the retardation at the time of voltage impression changes with places, and if the extent is remarkably large, the problem that display grace falls will occur.
[0214] In the composition shown in drawing 34 , the thickness d1 of the liquid crystal layer 30 on the upper conductive layer (except opening 14a) 14 differs from the thickness d2 of the liquid crystal layer 30 on the lower layer conductive layer 12 located in opening 14a (and opening 13a) by the thickness of a dielectric layer 13. When the liquid crystal layer 30 of thickness d1 and the liquid crystal layer 30 of thickness d2 are driven in the same voltage range, the variation of the retardation accompanying orientation change of the liquid crystal layer 30 differs mutually in response to the influence of the thickness of each liquid crystal layer 30. In the design which thought display grace as important when the relation between applied voltage and the amount of retardations of the liquid crystal layer 30 changed remarkably with places, permeability falls victim, if permeability is thought as important, the color temperature of a white display will shift and the problem that display grace falls victim will occur. Therefore, when using a liquid crystal display 500 as a penetrated type liquid crystal display, the thickness of a dielectric layer 13 has the thinner good one.
[0215] Next, the cross-section structure of one picture element field of a liquid crystal display 600 where the dielectric layer of a picture element electrode has a crevice is shown in drawing 35 .
[0216] The dielectric layer 13 which constitutes the picture element electrode 15 of a liquid crystal display 600 has crevice 13b corresponding to opening 14a of the upper conductive layer 14. Other structures have the same structure substantially with the liquid crystal display 500 shown in drawing 34.
[0217] In a liquid crystal display 600, since the dielectric layer 13 located in opening 14a of the upper conductive layer 14 which the picture element electrode 15 has is not removed completely, its thickness d3 of the liquid crystal layer 30 located in opening 14a is thinner than the thickness d2 of the liquid crystal layer 30 located in opening 14a in a liquid crystal display 500 by the thickness of the dielectric layer 13 in crevice 13b. Moreover, since the voltage impressed to the liquid crystal layer 30 located in opening 14a receives the voltage drop (capacitive component rate) by the dielectric layer 13 in crevice 13b, it becomes lower than the voltage impressed to the liquid crystal layer 30 on the upper conductive layer (field except opening 14a) 14. Therefore, by adjusting the thickness of the dielectric layer 13 in crevice 13b It controls making a mistake in the relation by the difference in the amount of retardations resulting from the difference in the thickness of the liquid crystal layer 30, and the place of the voltage impressed to the liquid crystal layer 30 (the amount of falls of the voltage impressed to the liquid crystal layer in opening 14a). The relation between applied voltage and a retardation can be prevented from being dependent on the place in a picture element field. More strictly, by adjusting the dielectric constant of the rate of a birefringence of a liquid crystal layer, liquid crystal layer thickness, and a dielectric layer and the thickness of a dielectric layer, and the thickness (depth of a crevice) of the crevice of a dielectric layer, relation between applied voltage and a retardation can be made uniform in the place in a picture element field, and a high-definition display is attained. As compared with the penetrated type display which has a dielectric layer with a flat front face especially, there is an advantage by which reduction (decline in the use efficiency of light) of the permeability by the fall of the voltage impressed to the liquid crystal layer 30 of the field corresponding to opening 14a of the upper conductive layer 14 is suppressed.
[0218] Although above-mentioned explanation explained the case where the same voltage as the upper conductive layer 14 and the lower layer conductive layer 12 which constitute the picture element electrode 15 was supplied, it can increase the variation of the composition of the liquid crystal display in which the composition which impresses voltage which is different in the lower layer conductive layer 12 and the upper conductive layer 14, then the display without display unevenness are possible. For example, it can prevent that the voltage impressed to the liquid crystal layer 30 changes with places in a picture element field by impressing the voltage high by the voltage drop by the dielectric layer 13 to the lower layer conductive layer 12 rather than the voltage impressed in the composition which has a dielectric layer 13 at the upper conductive layer 14 in opening 14a of the upper conductive layer 14.
[0219] Also in the liquid crystal displays 500 and 600 of this operation gestalt 4, in an operation of the slanting electric field produced by the picture element electrode 15 of the two-layer electrode structure equipped with the upper conductive layer 14 which has opening 14a like the liquid crystal display 100 of the operation gestalt 1, inclination orientation is carried out from liquid crystal molecule 30a of the edge section of opening 14a, and the liquid crystal layer 30 in a picture element field will be in a radial inclination orientation state focusing on opening 14a. Explanation of the phenomenon in which radial inclination orientation is formed is omitted here.

[0220] The structure of the picture element electrode of the liquid crystal display of this operation gestalt is explained in more detail, referring to drawing 36 . Drawing 36 (a) and (b) are the typical cross sections to which it expanded near the picture element electrode. Drawing 36 (a) shows the picture element electrode structure where the upper conductive layer 14 is not formed in the side attachment wall of opening 13a of a dielectric layer 13, and drawing 36 (b) shows the picture element electrode structure where the upper conductive layer 14 is formed also on the side attachment wall of opening 13a of a dielectric layer 13.

[0221] The structure which the liquid crystal displays 500 and 600 shown in drawing 34 and drawing 35 which were mentioned above have and which was shown in drawing 36 (a) is more desirable than the picture element electrode structure shown in drawing 36 (b). It is because the inclination of the slanting electric field by which the direction of the picture element electrode structure shown in drawing 36 (a) is generated by the edge section of opening 14a of the upper conductive layer 14 is enabled to carry out inclination orientation of the liquid crystal molecule 30a near the edge section to stability more strongly (for a tilt angle to be greatly) consequently (in most important direction). Since the part invades into the side attachment wall of opening 13a of a dielectric layer 13, as for the equipotential line EQ in opening 14a, it becomes stronger [the inclination in the edge section of opening 14a of the equipotential line EQ] than the inclination of a side attachment wall, so that the equipotential line EQ in drawing 36 (a) may show. therefore, liquid crystal molecule 30a by which orientation regulation is carried out at right angles to the front face (on the perpendicular orientation film (un-illustrating) formed on the side) of the side attachment wall of opening 13a can be made to incline uniquely (the example of illustration -- the direction of a counterclockwise rotation) Moreover, in order for liquid crystal molecule 30a on the side attachment wall of opening 13a to incline in the most important direction by slanting electric field so that drawing 36 (a) may show (rotation), the tilt angle theta of a side attachment wall has the smaller desirable one.

[0222] On the other hand, on a side attachment wall, if the upper conductive layer 14 is formed on the side attachment wall of opening 13a of a dielectric layer 13, as shown in the equipotential line EQ in drawing 36 (b), since the equipotential line EQ becomes parallel to the front face of the upper conductive layer 14, the inclination of the potential line EQ -- it can set in the edge section of opening 14a -- will become looser than the inclination of a side attachment wall. Therefore, since the equipotential line EQ intersects perpendicularly to liquid crystal molecule 30a by which orientation regulation is carried out at right angles to the front face (on the perpendicular orientation film (un-illustrating) formed on the upper conductive layer) of the side attachment wall of opening 13a of a dielectric layer 13, the problem that the direction where liquid crystal molecule 30a inclines is not decided uniquely may occur. In addition, in order to connect electrically the upper conductive layer 14 and the lower layer conductive layer 12, you may put a part of upper conductive layer 14 on a part of lower layer conductive layer 12. In this case, the need of preparing separately the contact hole for connecting electrically the upper conductive layer 14 and the lower layer conductive layer 12 is lost. A numerical aperture can be improved in the reflected type liquid crystal display using the upper conductive layer 14 especially formed on the flat front face (upper surface) of a dielectric layer 13 as a reflector (reflecting layer).

[0223] The above-mentioned explanation about the structure where a dielectric layer 13 has opening 13a is applied also to the composition in which a dielectric layer 13 has crevice 13b.

[0224] Although the upper conductive layer 14 illustrated the liquid crystal display which equipped the picture element field with the picture element electrode which has one opening 14a as a liquid crystal display of this operation gestalt, this operation gestalt is not restricted to the above-mentioned example, but can be applied to the liquid crystal display which has two or more opening 14a for every picture element field. The composition which the upper conductive layer 14 mentioned above does opening 14a correspondence of, and forms opening 13a or crevice 13b in a dielectric layer 13 is applicable to all the liquid crystal displays explained as an operation gestalt 1.

[0225] (Operation gestalt 5) One picture element field of the liquid crystal display 700 of the operation gestalt 5 is typically shown in drawing 37 . Drawing 37 (a) is the cross section of a liquid crystal display 700, and drawing 37 (b) is the plan of a liquid crystal display 700. Drawing 37 (a) is equivalent to the cross section which met the 37A-37A' line in drawing 37 (b). Since the liquid crystal display 700 has the same structure substantially with the liquid crystal display 500 of the operation gestalt 4 except that the lower layer conductive layer 12 has opening 12a further, explanation of common structure is omitted here.

[0226] The lower layer conductive layer of the picture element electrode 15 of a liquid crystal display 700 has opening 12a in the field exposed in opening 13a of a dielectric layer 13. As shown in drawing 37 (b), circular opening 13a of a dielectric layer 13 is prepared corresponding to circular opening 14a prepared in the center of a picture element field, i.e., the center section of the upper conductive layer 14. There is opening 12a currently formed in the lower layer conductive layer 12 exposed in opening 13a of a dielectric layer 13 in the center of opening 14a and opening 13a.

[0227] If voltage is impressed to the liquid crystal layer 30 of this liquid crystal display 700, the electric field expressed

with the potential line EQ, such as having been shown in drawing 37 (a), will occur. The potential line EQ, such as having fallen in the edge section EG of opening 14a of the upper conductive layer 14, falls further within opening 12a of the lower layer conductive layer 12.

[0228] Since slanting electric field are formed also in the edge section of opening 12a of the lower layer conductive layer 12, orientation change of liquid crystal molecule 30a in the liquid crystal layer 30 to which voltage was impressed The inclination of liquid crystal molecule 30a in the edge section of opening 14a and the edge section of opening 12a serves as a trigger, and takes place, and radial inclination orientation is formed focusing on liquid crystal molecule 30a in the state where orientation was carried out perpendicularly at the center of opening 12a. Thus, since the position of the radial inclination orientation of liquid crystal molecule 30a in opening 14a is stably [correctly and] controllable by preparing opening 12a in the center of the lower layer conductive layer 12 in the position which counters opening 14a in addition to opening 14a of the upper conductive layer 14, a speed of response can both be improved as if radial inclination orientation is further stable.

[0229] In addition, since voltage is not impressed to the liquid crystal layer 30 corresponding to opening 12a, as for opening 12a, it is desirable that it is not large. It is desirable that it is 8 micrometers or less typically. What is necessary is just to form it in one center of every opening 14a, since what is necessary is to form opening 12a only in the center of radial inclination orientation. It is the same as having mentioned above about opening 14a that the configuration of opening 12a is not restricted circularly, but an ellipse and a polygon may be used.

[0230] Although the operation of opening 12a was explained about the composition which formed opening 13a in the dielectric layer 13, it can use, when using the case (drawing 35) where crevice 13b is formed in a dielectric layer 13, and the flat dielectric layer 13 (for example, drawing 1). That is, the lower layer conductive layer 12 of the picture element electrode 15 which explained the liquid crystal display 700 to the example can combine suitably the composition which has opening 12a to the field which counters opening 14a of the upper conductive layer 14 with the liquid crystal display of the operation gestalten 1 and 2 mentioned above. However, opening 12a is small (typically diameter of 8 micrometers or less), and sufficient effect may not be acquired when the dielectric layer 13 on opening 12a is thick.

[0231] (Application to a transparency reflective two-ways type liquid crystal display) A transparency reflective two-ways type liquid crystal display (it abbreviates to a "two-ways type liquid crystal display" hereafter) points out the liquid crystal display which has the transparency field which displays by the transparent mode in a picture element field, and the reflective field which displays in reflective mode. Typically, a transparency field and a reflective field are prescribed by a transparent electrode and the reflector. It can replace with a reflector and the combined structure of a reflecting layer and a transparent electrode can also prescribe a reflective field.

[0232] This two-ways type liquid crystal display can also be displayed on changing and displaying reflective mode and the transparent mode or **** with both display modes. It follows, for example, an ambient light can be realized the display in reflective mode under bright environment, and the display of the transparent mode can be realized in a dark environment. Moreover, if both modes are displayed simultaneously, the fall of the contrast ratio seen when an ambient light uses the liquid crystal display of the transparent mode under bright environment (state in which the light and the sunlight of a fluorescent lamp carry out incidence to the screen at an angle of direct specification) can be suppressed. Thus, the fault of a penetrated type liquid crystal display is suppliable. In addition, the ratio of the area of a transparency field and a reflective field may be suitably set up according to the use of a liquid crystal display. Moreover, in the liquid crystal display chiefly used as a penetrated type, even the grade which cannot perform a display with reflective mode is suppliable with the fault of the penetrated type liquid crystal display mentioned above, even if it makes small the rate of surface ratio of a reflective field.

[0233] The structure of a two-ways type liquid crystal display and operation are explained referring to drawing 38 A, drawing 38 B, and drawing 38 C. In the two-ways type liquid crystal display 550 which indicated the two-ways type liquid crystal display 150 shown in drawing 38 A to be the liquid crystal display 100 of the operation gestalt 1 to drawing 38 B, the two-ways type liquid crystal display 650 indicated to be the liquid crystal display 500 of the operation gestalt 4 to drawing 38 C has the same structure fundamentally with the liquid crystal display 600 of the operation gestalt 4, respectively. A two-ways type liquid crystal display is obtained by not being restricted to these illustrated examples, but making either the upper electrode layer or the lower layer electrode layers into a transparent conductive layer in all the liquid crystal displays explained with the operation gestalten 1, 2, and 3, and making another side into a reflective conductive layer.

[0234] Upper conductive-layer 14T of the picture element electrode 15 are formed from the transparent conductive layer, and the liquid crystal display 150 shown in drawing 38 A is formed in the conductive layer and type target which have a light reflex property for lower layer conductive-layer 12R from the metal layer. The picture element field specified by the picture element electrode 15 has the transparency field T specified as the reflective field R specified by

reflective lower layer conductive-layer 12R by transparence upper conductive-layer 14T. In addition, if the contribution to the lap of transparence upper conductive-layer 14T and reflective lower layer conductive-layer 12R and the display of light which carries out incidence aslant to a substrate normal (screen normal) is taken into consideration, although the reflective field R and the transparency field T become a heavy bird clapper mutually near [the] a boundary, they will be made to distinguish and illustrate both fields from a substrate normal with the display mode by the light which carries out incidence for simplicity.

[0235] Since the fundamental structure of a liquid crystal display 150 is the same as a liquid crystal display 100, a liquid crystal layer is driven similarly substantially. That is, the liquid crystal layer 30 takes the radial inclination orientation stabilized by operation of the picture element electrode 15 of two-layer structure at the time of voltage impression, and the liquid crystal display excellent in the viewing-angle property is realized.

[0236] Below, the display action of a liquid crystal display 150 is explained.

[0237] When a liquid crystal display 150 is in a white display state, the light which carries out incidence to the transparency field T passes a substrate 11, a dielectric layer 13, and transparence upper conductive-layer 14T one by one from the back light (un-illustrating) prepared in the outside (under [in drawing]) of TFT substrate 100a, and outgoing radiation is carried out to the opposite substrate 100b side through the liquid crystal layer 30. A substrate 21 and a counterelectrode 22 are passed one by one, and through the liquid crystal layer 30 and a dielectric layer 13, incidence is carried out to reflective lower layer conductive-layer 12R, it is reflected in it, the light (typically ambient light) which carries out incidence from the opposite substrate 100b side follows a reverse path, and outgoing radiation is carried out to the opposite substrate 100b side.

[0238] Thus, the light which displays reflective mode passes the liquid crystal layer 30 twice to the light which displays by the transparent mode passing the liquid crystal layer 30 only once. Therefore, if the whole (the transparency field T and the reflective field R) picture element field is covered and the same voltage is impressed to the uniform liquid crystal layer 30 of thickness (d5) The variation of the retardation which the transmitted light receives by the liquid crystal layer 30, and the variation of the retardation which the reflected light receives from the liquid crystal layer 30 stop being in agreement. The same gradation cannot be simultaneously displayed on the liquid crystal layer 30 by the transmitted light and the reflected light at the time of voltage impression, but the problem that display grace falls occurs.

[0239] However, in the liquid crystal display 150 by this invention, generating of the above-mentioned problem is avoidable so that it may explain below.

[0240] Since the liquid crystal display 150 was equipped with the picture element electrode 15 of two-layer structure, as the liquid crystal display of the operation gestalt 1 was explained, since the voltage (voltage between lower layer conductive-layer 12R and a counterelectrode 22) impressed to the liquid crystal layer 30 in the reflective field R receives the voltage drop by the dielectric layer 13, it becomes lower than the voltage (voltage between upper conductive-layer 14T and a counterelectrode 22) impressed to the liquid crystal layer 30 in the transparency field T. Consequently, there is less retardation change by the liquid crystal layer 30 in the reflective field R than retardation change of the liquid crystal layer 30 in the transparency field T. Therefore, the retardation change by the liquid crystal layer 30 in the transparency field T and the retardation change by the liquid crystal layer 30 in the reflective field R can be close brought by adjusting the dielectric constant and thickness of the rate of a birefringence of the liquid crystal layer 30 and thickness, and a dielectric layer 13. That is, the influence of the optical path length to the retardation of the reflected light can be compensated by adjusting applied voltage.

[0241] If the liquid crystal display 150 of this invention is used as mentioned above, it will become possible to bring mutually the voltage-permeability property of the transparent mode, and the voltage-reflection factor property in reflective mode close, and will excel in an angle-of-visibility property in an omnidirection, and a transparency reflective two-ways type liquid crystal display with high visibility will be obtained in all environments.

[0242] Next, the structure of other two-ways type liquid crystal displays 550 and operation are explained, referring to drawing 38 B. Upper conductive-layer 14R of the picture element electrode 15 of the two-ways type liquid crystal display 550 is formed from the conductive layer which has a light reflex property, and lower layer conductive-layer 12T are formed from the transparent conductive layer. The picture element field specified by the picture element electrode 15 has the transparency field T specified as the reflective field R specified by reflective upper conductive-layer 14R by transparence lower layer conductive-layer 12T. Since the fundamental composition of others of the two-ways type liquid crystal display 550 is the same as that of the liquid crystal display 500 shown in drawing 34, the explanation is omitted here.

[0243] Thickness of the liquid crystal layer 30 in opening 14a of d1 and reflective upper conductive-layer 14R and opening 13a of a dielectric layer 13 (namely, inside of the transparency field T) is set to d2 for the thickness of the liquid crystal layer 30 in fields other than opening 14a of reflective upper conductive-layer 14R of a liquid crystal

display 550 (namely, inside of the reflective field R). The light (reflected light) which contributes to the display in reflective mode passes the liquid crystal layer 30 of the thickness d1 in the reflective field R twice, and the light (transmitted light) which contributes to the display of the transparent mode passes the liquid crystal layer 30 of the thickness d2 in the transparency field T once. Therefore, d1=d2/2 then the reflected light, and the transmitted light can make equal mutually distance which passes the liquid crystal layer 30, respectively by making thickness of a dielectric layer 13 equal to d1. Moreover, since transparence lower layer conductive-layer 12T have the composition (composition in which a dielectric layer 13 does not exist on transparent lower layer conductive-layer 12T) exposed in opening 13a of a dielectric layer 13, the picture element electrode 15 of a liquid crystal display 550 of the voltage impressed to the liquid crystal layer 30 in the transparency field T is equal to the voltage impressed to the liquid crystal layer 30 in the reflective field R.

[0244] Therefore, when setting up so that the thickness d1 of the liquid crystal layer 30 in the reflective field R and the thickness d2 of the liquid crystal layer 30 in the transparency field T might satisfy the relation between 2 and d1=d2 and lower layer conductive-layer 12R and the same voltage as upper conductive-layer 14T are impressed, the variation of the retardation which the transmitted light receives by the liquid crystal layer 30, and the variation of the retardation which the reflected light receives from the liquid crystal layer 30 are in agreement. However, it is more more desirable to shift from the relation between 2 and d1=d2 in consideration of this difference, since field strength differs even if the voltage to impress is equal, when the thickness of the liquid crystal layer 30 in the reflective field R differs from the thickness of the liquid crystal layer 30 in the transparency field T mutually.

[0245] If the liquid crystal display 550 of this invention is used as mentioned above, it will become possible to bring mutually the voltage-permeability property of the transparent mode, and the voltage-reflection factor property in reflective mode close, and will excel in an angle-of-visibility property in an omnidirection, and a transparency reflective two-ways type liquid crystal display with high visibility will be obtained in all environments.

[0246] Next, the structure of other two-ways type liquid crystal displays 650 and operation are explained, referring to drawing 38 C. Upper conductive-layer 14R of the picture element electrode 15 of the two-ways type liquid crystal display 650 is formed from the conductive layer which has a light reflex property, and lower layer conductive-layer 12T are formed from the transparent conductive layer. The picture element field specified by the picture element electrode 15 has the transparency field T specified as the reflective field R specified by reflective upper conductive-layer 14R by transparence lower layer conductive-layer 12T. Since the fundamental composition of others of the two-ways type liquid crystal display 650 is the same as that of the liquid crystal display 600 shown in drawing 35, the explanation is omitted here.

[0247] Thickness of the liquid crystal layer 30 in opening 14a of d1 and reflective upper conductive-layer 14R and crevice 13b of a dielectric layer 13 (namely, inside of the transparency field T) is set to d3 for the thickness of the liquid crystal layer 30 in fields other than opening 14a of reflective upper conductive-layer 14R of a liquid crystal display 650 (namely, inside of the reflective field R). The thickness d3 of the liquid crystal layer 30 in the transparency field T is thicker than the thickness d1 of the liquid crystal layer 30 in the reflective field R by the depth of crevice 13b of a dielectric layer 13. The light (reflected light) which contributes to the display in reflective mode passes the liquid crystal layer 30 of the thickness d1 in the reflective field R twice, and the light (transmitted light) which contributes to the display of the transparent mode passes the liquid crystal layer 30 of the thickness d3 in the transparency field T once. That is, the distance in which the transmitted light passes through the inside of the liquid crystal layer 30 is d3, and the distance in which the reflected light passes through the inside of the liquid crystal layer 30 is in 2 and d1.

[0248] On the other hand, since the voltage impressed to the liquid crystal layer 30 in the transparency field T receives the voltage drop (capacitive component rate) by the dielectric layer 13 in crevice 13b, it becomes lower than the voltage impressed to the liquid crystal layer 30 of the reflective field R. Therefore, by adjusting the thickness of the dielectric layer 13 in crevice 13b The difference in the amount of retardations resulting from the difference in distance which passes through the inside of the liquid crystal layer 30, You can control making a mistake in the relation by the place of the voltage impressed to the liquid crystal layer 30 (the amount of falls of the voltage impressed to the liquid crystal layer 30 in the transparency field T), and the relation between applied voltage and a retardation can make it in agreement in the transparency field T and the reflective field R. More strictly, by adjusting the dielectric constant of the rate of a birefringence of a liquid crystal layer, liquid crystal layer thickness, and a dielectric layer and the thickness of a dielectric layer, and the thickness (depth of a crevice) of the crevice of a dielectric layer, a transparency field and a reflective field can be covered and relation between applied voltage and a retardation can be made uniform.

[0249] If the liquid crystal display 650 of this invention is used as mentioned above, it will become possible to bring mutually the voltage-permeability property of the transparent mode, and the voltage-reflection factor property in reflective mode close, and will excel in an angle-of-visibility property in an omnidirection, and a transparency reflective two-ways type liquid crystal display with high visibility will be obtained in all environments.

[0250] Although the front face of a reflective conductive layer (the upper layer or lower layer conductive layer) was evenly drawn for the transparency reflective two-ways type liquid crystal displays 150, 550, and 650 by drawing 38 A, and 38B and 38C, the function to which diffuse reflection (or dispersion) of the light is carried out can also be given by processing the front face of a reflective conductive layer in the shape of irregularity. By giving an optical diffusion function to a reflective conductive layer, there is no parallax and the display in the high reflective mode of display grace can be realized.

[0251] As a method of forming irregularity in the front face of a reflective conductive layer, the method currently indicated by JP,6-75238,A is mentioned, for example.

[0252] For example, a dielectric layer 13 is formed using a photoresist (any of a negative mold or a positive type are sufficient), and irregularity is processed into the front face of a resist layer in the photolithography process using the photo mask which has the translucent part (or shading section) of a predetermined pattern. The resist layer in which irregularity was formed is heated if needed, the phenomenon (heat who) which deforms the front face of a resist layer with heat is used, and it is good also as smooth (continuously wavelike) in irregularity. Thus, irregularity can be formed in the front face of the reflective upper conductive layer by forming the reflective upper conductive layer on the front face which has the irregularity of the formed dielectric layer 13.

[0253] However, like the two-ways type liquid crystal displays 550 and 650 shown in drawing 38 B and 38C, as the composition using reflective upper conductive-layer 14R was shown in drawing 40 (a) and (b), it is desirable to suppose that the height of the dielectric layer 13 in the edge section of opening 14a is uniform.

[0254] In the liquid crystal display of this invention, radial inclination orientation of the liquid crystal molecule is carried out using the slanting electric field generated by the edge section of opening 14a by the picture element electrode 15 of two-layer structure equipped with reflective upper conductive-layer 14R which has opening 14a.

[0255] However, when the irregularity (the circle in drawing shows a crevice or heights typically.) formed in the front face of a dielectric layer 13 is arranged so that it may lap with opening 13a of a dielectric layer 13, or crevice 13b as shown in drawing 39 (a), as shown in drawing 39 (b), the thickness of the dielectric layer 13 in the edge section of opening 14a changes with places. Thus, if irregularity exists in the front face of the dielectric layer 13 of the edge section, the direction of the slanting electric field generated by the edge section (the inclination direction of the equipotential line) will change with places, the stability of the radial inclination orientation centering on opening 14a falls, or the state of radial inclination orientation changes with positions of opening 14a.

[0256] Then, if irregularity is not formed in the front face of the surrounding dielectric layer 13 of opening 14a (opening 13a or crevice 13b of a dielectric layer 13) but it is a flat front face as shown in drawing 40 (a), as shown in drawing 40 (b), the structure where cover the perimeter of opening 14a and the dielectric layer 13 near the edge section has uniform thickness will be acquired.

[0257] In addition, you may prepare the diffusion layer which has an optical diffusion function in the optical incidence side of a reflective conductive layer instead of giving an optical diffusion function to a reflective conductive layer by processing the front face of a reflective conductive layer in the shape of irregularity. A diffusion layer may be prepared inside a liquid crystal panel (liquid crystal layer side of a substrate), and may be prepared outside (observer side). As for a diffusion layer, it is desirable to prepare in the reflective field of a liquid crystal display alternatively.

[0258] (Arrangement of a polarizing plate and a phase contrast board) Although the so-called perpendicular orientation type liquid crystal display with which the liquid crystal molecule which has a negative dielectric constant anisotropy is equipped with the liquid crystal layer which carries out perpendicular orientation at the time of no voltage impressing can be displayed with various display modes, its birefringence mode displayed in it by controlling the rate of a birefringence of a liquid crystal layer by electric field is desirable from a viewpoint of display grace. The arrangement relation of the polarizing plate and phase contrast board (wavelength plate) for improving the display grace of the perpendicular orientation type liquid crystal display in birefringence mode is explained below. The liquid crystal display in birefringence mode can be obtained by preparing the polarizing plate of a couple in the outside (the liquid crystal layer 30 and opposite side) of the substrate (for example, a TFT substrate and an opposite substrate) of the couple of all the liquid crystal displays explained with the previous operation gestalten 1-5.

[0259] First, arrangement of a polarizing plate is explained, referring to drawing 41 and drawing 42. Drawing 41 shows the voltage state where it does not impress (OFF state), and drawing 42 shows the voltage impression state (ON state), respectively.

[0260] Drawing 41 (a) is the typical cross section of liquid crystal display 100A which has polarizing plates 50a and 50b, respectively on each outside of TFT substrate 100a and opposite substrate 100b. Liquid crystal display 100A may be the arbitrary liquid crystal displays of the previous operation gestalten 1-5. As shown in drawing 41 (a), liquid crystal molecule 30a in the liquid crystal layer 30 is in a perpendicular orientation state at the time of no voltage impressing.

[0261] Drawing 41 (b) shows typically the arrangement relation of the transparency shaft (polarization shaft) PA of polarizing plates 50a and 50b when seeing liquid crystal display 100A along the direction of a screen normal (the direction of a substrate normal) from the opposite substrate 100b side (observer side). The solid line arrow PA 1 in drawing shows the transparency shaft of polarizing plate (above) 50b, and the dashed line arrow shows the transparency shaft PA 2 of polarizing plate (below) 50a, respectively. As shown in drawing 41 (b), the transparency shafts PA2 and PA1 of polarizing plates 50a and 50b are arranged so that it may intersect perpendicularly mutually. That is, polarizing plates 50a and 50b are arranged at the cross Nicol's prism state.

[0262] To a substrate side, since it is perpendicular, the axial direction of liquid crystal molecule 30a of the liquid crystal layer 30 at the time of no voltage impressing does not give phase contrast to the polarization which carries out incidence at right angles to the liquid crystal layer 30. In addition, a perpendicular thing is meant as "it is a perpendicular to the liquid crystal layer 30" to the field of the liquid crystal layer 30 parallel to Substrates 100a and 100b.

[0263] Since it does not give phase contrast to the polarization which carries out vertical incidence, the liquid-crystal layer 30 of a perpendicular orientation state serves as the linearly polarized light which has the polarization direction which met the transparency shaft PA 2 by passing polarizing plate 50a, carries out incidence at right angles to the liquid-crystal layer 30, and it carries out incidence of the light which carries out incidence at right angles to the liquid-crystal layer 30 from the TFT substrate 100a side, for example to polarizing plate 50b through the liquid-crystal layer 30, with the polarization direction maintained. Since the transparency shafts PA2 and PA1 of polarizing plate 50a and polarizing plate 50b lie at right angles mutually, the linearly polarized light which passed opposite substrate 100b is absorbed by polarizing plate 50b. Consequently, liquid crystal display 100A in voltage the state where it does not impress becomes a black display.

[0264] In the state of voltage impression, as shown in drawing 42 (a) and (b), radial inclination orientation of the liquid crystal molecule 30a is carried out. In drawing 42 (a) and (b), although one radial inclination orientation field is illustrated for simplicity, as the previous operation gestalten 1-5 explained, two or more radial inclination orientation fields may be formed in one picture element field. Also in the following drawings, although one radial inclination orientation may be illustrated, two or more radial inclination orientation fields may be formed in one picture element field.

[0265] By passing polarizing plate 50a, the liquid crystal layer 30 containing liquid crystal molecule 30a which carried out radial inclination orientation serves as the linearly polarized light which has the polarization direction in alignment with the transparency shaft PA 2, and carries out incidence of the light which carries out incidence at right angles to the liquid crystal layer 30 from the TFT substrate 100a side at right angles to the liquid crystal layer 30. Liquid crystal molecule 30a which is carrying out orientation so that the seen axial direction is parallel or may intersect perpendicularly from a substrate normal to the polarization direction of this linearly polarized light, and liquid crystal molecule (liquid crystal molecule located at center of radial inclination orientation) 30a in a perpendicular orientation state do not give phase contrast to the linearly polarized light which carried out incidence at right angles to the liquid crystal layer 30. Therefore, the linearly polarized light which carried out incidence to the field which has liquid crystal molecule 30a in the above-mentioned direction of orientation passes the liquid crystal layer 30, with a polarization state maintained, and it carries out incidence to polarizing plate 50b through opposite substrate 100b. Since the transparency shafts PA2 and PA1 of polarizing plate 50a and polarizing plate 50b lie at right angles mutually, this linearly polarized light is absorbed by polarizing plate 50b. Namely, some fields of the liquid crystal layer 30 of a radial inclination orientation state will be in a black display state also in a voltage impression state.

[0266] As for the linearly polarized light which carried out incidence to the field containing liquid crystal molecule 30a other than liquid crystal molecule 30a which is carrying out orientation so that the axial direction seen from the substrate normal among the linearly polarized lights which, on the other hand, have the polarization direction parallel to the transparency shaft PA 2 of polarizing plate 50a is parallel or may intersect perpendicularly to the polarization direction of this linearly polarized light, and liquid crystal molecule 30a in a perpendicular orientation state, phase contrast is given by the liquid crystal layer 30. That is, the linearly polarized light has a polarization state broken down, and turns into elliptically polarized light. Moreover, the axial direction of liquid crystal molecule 30a when seeing from the polarization direction and the direction of a substrate normal of the incidence linearly polarized light serves as the maximum in the field which makes 45 degrees, and this phase contrast becomes small as the axial direction of liquid crystal molecule 30a when seeing from a substrate normal approaches parallel or a rectangular cross to the polarization direction of the incidence linearly polarized light. The axial direction of liquid crystal molecule 30a when seeing from a substrate normal to the polarization direction of the incidence linearly polarized light in therefore, the field whose molecule shaft of liquid crystal molecule 30a except parallel or a rectangular cross is not parallel to the direction of a substrate normal And phase contrast is given to the linearly polarized light in which the axial direction of liquid crystal

molecule 30a when seeing from a substrate normal carries out incidence to the liquid crystal layer 30 in fields other than parallel or a rectangular cross, and the linearly polarized light is broken down (generally it becomes elliptically polarized light). Therefore, if the polarization from which the polarization state was changed by passing the liquid crystal layer 30 carries out incidence to polarizing plate 50b, the part will penetrate polarizing plate 50b. Since it is dependent on the size of the phase contrast given by the liquid crystal layer 30, the amount of this polarization to penetrate may be adjusted by controlling the voltage impressed to the liquid crystal layer 30. Therefore, a gradation display is attained by controlling the voltage impressed to the liquid crystal layer 30.
[0267] (lambda/4 board) Display grace can be further improved by preparing the one wave plate for 4 minutes (lambda/4 board) between the polarizing plates of a couple and liquid crystal layers which have been arranged at the both sides of a liquid crystal layer. That is, the use efficiency of light can be raised by carrying out incidence of the circular polarization of light to the liquid crystal layer 30 which presents radial inclination orientation. For example, the liquid crystal display which carries out incidence of the linearly polarized light to the perpendicular orientation type liquid-crystal layer of the quadrisection multi-domain orientation currently indicated by JP,10-301114,A can realize a brighter (the use efficiency of light is high) liquid crystal display, if the composition incidence of the circular polarization of light is carried out [composition] to the liquid crystal layer which presents the radial inclination orientation from which the direction of orientation changes continuously is adopted to the ability to be unable to make the border area between the domains of a multi-domain contribute to a display.
[0268] An operation of lambda/4 board is explained referring to drawing 43 and drawing 44. Drawing 43 shows the voltage state where it does not impress, and drawing 44 shows the voltage impression state typically, respectively. In addition, in this application specification, unless it refuses especially, "lambda/4 board" makes the phase contrast board with which the thing of a monolayer is pointed out, the laminating of two or more phase contrast boards is carried out, and it is satisfied of lambda/4 conditions as a whole call it especially "wide band lambda / 4 board." Here, the composition which used lambda/4 board of a monolayer is explained.
[0269] Liquid crystal display 100B shown in drawing 43 and drawing 44 has polarizing plates 50a and 50b and lambda/4 boards 60a and 60b on both sides of a liquid crystal display 100. lambda/4 boards 60a and 60b are phase contrast boards which change into the circular polarization of light the linearly polarized light which has the 45-degree polarization direction to the lagging axis at conversion or the linearly polarized light which has the 45-degree polarization direction for the circular polarization of light to the lagging axis conversely. In addition, it is not restricted to a liquid crystal display 100, but the arbitrary liquid crystal displays of the operation gestalten 1-5 can be used.
[0270] It 4 board 60a [lambda/] Has liquid crystal display 100B between TFT substrate 100a and polarizing plate 50a prepared in the outside (the liquid crystal layer 30 is an opposite side), and it has lambda/4 board 60b between opposite substrate 100b and polarizing plate 50b prepared in the outside. Each transparency shaft PA2 and PA1 of polarizing plates 50a and 50b and each lagging axis SL2 and SL1 of lambda/4 boards 60a and 60b are arranged as shown in drawing 43 (b).
[0271] It is arranged so that the lagging axis SL 2 of lambda/4 board 60a may make the transparency shaft PA 2 of polarizing plate 50a, and the angle of 45 degrees and the lagging axis SL 1 of nothing, and lambda/4 board 60b may make the transparency shaft PA 1 of polarizing plate 50b, and the angle of 45 degrees. It is arranged so that 45 degrees may be made in the direction (both left-handed rotation [For example, if all are the same direction and right-handed rotation when it sees along the direction of a substrate normal from the opposite substrate 100b side, as illustrated and both are right-handed rotation and left-handed rotation]) where the angle which the transparency shafts PA1 and PA2 and lagging axes SL2 and SL1 make is the same.
[0272] Since the liquid crystal layer 30 is in a perpendicular orientation state at the time of no voltage impressing as shown in drawing 43 (a), phase contrast is not given to the light which carries out incidence at right angles to the liquid crystal layer 30. therefore -- for example, the light which carries out incidence at right angles to the liquid crystal layer 30 from the TFT substrate 100a side -- polarizing plate 50a -- a passage -- the polarization direction -- the linearly polarized light of 2 receive 45 degrees of lagging axes SL of lambda/4 board 60a -- becoming -- lambda / 4 board 60a -- incidence -- carrying out . This linearly polarized light is changed into the circular polarization of light by passing lambda/4 board 60a. The circular polarization of light passes the liquid crystal layer 30, with a polarization state maintained, and it carries out incidence to lambda/4 board 60b. By passing lambda/4 board 60b, the polarization direction serves as the linearly polarized light of 45 degrees to a lagging axis SL 1, and carries out incidence of the circular polarization of light to polarizing plate 50b. Since the polarization direction of the linearly polarized light which passed lambda/4 board 60b lies at right angles to the transparency shaft PA 1 of polarizing plate 50b, this linearly polarized light is absorbed by polarizing plate 50b. Therefore, liquid crystal display 100B will be in a black display state in the state of no voltage impressing.
[0273] In the state of voltage impression, as shown in drawing 44 (a) and (b), radial inclination orientation of the liquid

crystal molecule 30a is carried out.
[0274] The liquid crystal layer 30 containing liquid crystal molecule 30a which carried out radial inclination orientation gives the phase contrast according to the polarization direction to the light which carries out incidence to the liquid crystal layer 30. For example, by passing polarizing plate 50a, the polarization direction serves as the 45-degree linearly polarized light to the lagging axis SL 2 of lambda/4 board 60a, and carries out incidence of the light which carries out incidence at right angles to the liquid crystal layer 30 from the TFT substrate 100a side to lambda/4 board 60a. This linearly polarized light is changed into the circular polarization of light by passing lambda/4 board 60a. At this time, liquid crystal molecule (liquid crystal molecule located at center of radial inclination orientation) 30a in a perpendicular orientation state does not give phase contrast to the polarization which carried out incidence at right angles to the liquid crystal layer 30. Therefore, the circular polarization of light which carried out incidence to the field as for which liquid crystal molecule 30a is carrying out perpendicular orientation passes the liquid crystal layer 30, with a polarization state maintained, and it carries out incidence to lambda/4 board 60b. By passing lambda/4 board 60b, the polarization direction serves as the linearly polarized light of 45 degrees to a lagging axis SL 1, and carries out incidence of the circular polarization of light to polarizing plate 50b. Since the polarization direction of the linearly polarized light which passed lambda/4 board 60b lies at right angles to the transparency shaft PA 1 of polarizing plate 50b, this linearly polarized light is absorbed by polarizing plate 50b. Namely, some fields (only perpendicular orientation field) of the liquid crystal layer 30 of a radial inclination orientation state will be in a black display state also in a voltage impression state.
[0275] As for the circular polarization of light which carried out incidence to the field containing liquid crystal molecule 30a other than liquid crystal molecule 30a which is in a perpendicular orientation state on the other hand among the circular polarization of lights changed from the linearly polarized light by lambda/4 board 60b, phase contrast is given by the liquid crystal layer 30. That is, the polarization state of the circular polarization of light changes (generally it becomes elliptically polarized light). Therefore, a part of polarization which passed lambda/4 board 60b penetrates polarizing plate 50b. Since it is dependent on the size of the phase contrast given by the liquid crystal layer 30, the amount of this polarization to penetrate may be adjusted by controlling the voltage impressed to the liquid crystal layer 30. Therefore, a gradation display is attained by controlling the voltage impressed to the liquid crystal layer 30.
[0276] As having mentioned above, the liquid crystal display 100 B which has further lambda/4 boards 60a and 60b has few the fields where the field which will be in a black display state in the state of voltage impression serves as a black display in the state of voltage impression as compared with the liquid crystal display 100 A from which it is only a perpendicular orientation field (center of radial inclination orientation), and the field which carried out orientation in the direction which is parallel or intersects perpendicularly with a perpendicular orientation field and the transparency shaft of a polarizing plate will be in a black That is, rather than liquid crystal display 100A, liquid crystal display 100B has high efficiency for light utilization (effective numerical aperture), and can realize the high display of brightness.
[0277] Generally, it is not easy to lose completely the wavelength dispersion of lambda/4 boards 60a and 60b of a monolayer. For example, it will shift from lambda/4 conditions as the wavelength of light will shift from 550nm, if lambda/4 board produced so that lambda/4 conditions might be satisfied to the light whose wavelength with the highest visibility is 550nm as lambda/4 boards 60a and 60b is used. Consequently, in liquid crystal display 100B, in a black display state, the light wavelength shifted [light] from 550nm passes polarizing plate 50b, consequently a coloring phenomenon occurs.
[0278] In order to suppress generating of the coloring phenomenon in this black display state, the transparency shafts PA2 and PA1 of polarizing plates 50a and 50b are made to intersect perpendicularly mutually, and the lagging axes SL2 and SL1 of lambda/4 boards 60a and 60b are made to intersect perpendicularly mutually like liquid crystal display 100C shown in drawing 45. The transparency shaft PA 2 of polarizing plate 50a, the lagging axis SL 2 of lambda/4 board 60a and the transparency shaft PA of polarizing plate 50b 1, and the lagging axis SL 1 of lambda/4 board 60b are making the angle of 45 degrees in the same direction like liquid crystal display 100B, respectively. Thus, since the wavelength dispersion of the refractive-index anisotropy which each of lambda/4 board 60a, and lambda/4 board 60b has by arranging the lagging axis SL 2 of lambda/4 board 60a and the lagging axis SL 1 of lambda/4 board 60b so that it may intersect perpendicularly mutually offsets each other mutually, in a black display state, the light of the latus wavelength range is absorbed by polarizing plate 50b, and a good black display is realized. It is desirable to use especially lambda/4 board (lambda/4 board formed from the material same at least) same as lambda/4 board 60a and lambda/4 board 60b. If such composition is adopted, a liquid crystal display can be constituted more cheaply than the composition using wide band lambda / 4 board explained below.
[0279] As other methods of suppressing generating of the coloring phenomenon in the black display state resulting from the wavelength dispersion of the refractive-index anisotropy of lambda/4 boards 60a and 60b of the monolayer

mentioned above, it replaces with lambda/4 board of a monolayer, and there is a method using wide band lambda / 4 board. By carrying out the laminating of two or more phase contrast boards, wide band lambda / 4 board offsets the influence of a wavelength dispersion, covers the whole (400nm - 800nm) light, and satisfies lambda/4 conditions. Wide band lambda / 4 board can be formed by carrying out the laminating of lambda/4 board of a monolayer, and the half-wave plate ("lambda/2 board" being called hereafter.) of a monolayer.
[0280] Liquid crystal display 100D shown in drawing 46 has polarizing plates 50a and 50b, lambda/4 boards 60a and 60b, and lambda/2 boards 70a and 70b on both sides of a liquid crystal display 100. Sequentially from the liquid crystal layer 30 side, lambda/4 board 60a, lambda/2 board 70a, and polarizing plate 50a are prepared, and lambda/4 board 60b, lambda/2 board 70b, and polarizing plate 50b are prepared in the outside of opposite substrate 100b sequentially from the liquid crystal layer 30 side on the outside (it is an opposite side in the liquid crystal layer 30) of TFT substrate 100a.
[0281] As lambda/4 board 60b arranged on opposite substrate 100b, lambda/2 board 70b, and polarizing plate 50b are shown in drawing 46 (b), each optical axis is arranged. When setting the angle between the transparency shaft PA 1 of polarizing plate 50b, and the lagging axis SL 3 of lambda/2 board 70b to alpha (degree), it is arranged so that the angle between the transparency shaft PA 1 of polarizing plate 50b and the lagging axis SL 1 of lambda/4 board 60b may serve as 45 degree of 2 ****.
[0282] On the other hand, as lambda/4 board 60a arranged on TFT substrate 100a, lambda/2 board 70a, and polarizing plate 50a are shown in drawing 46 (c), each optical axis is arranged. When setting the angle between the transparency shaft PA 2 of polarizing plate 50a, and the lagging axis SL 4 of lambda/2 board 70a to beta (degree), it is arranged so that the angle between the transparency shaft PA 2 of polarizing plate 50a and the lagging axis SL 2 of lambda/4 board 60a may serve as 45 degree of 2 ****. Moreover, this angle between the transparency shaft PA 2 of polarizing plate 50a and the lagging axis SL 2 of lambda/4 board 60a (45 degree of 2 ****) is set up so that the angle (45 degree of 2 ****) and sign between the transparency shaft PA 1 of polarizing plate 50b and the lagging axis SL 1 of lambda/4 board 60b may be in agreement. That is, when the angle between PA1 and a lagging axis SL 1 is 2alpha+45 degree, it is set up so that the angle between the transparency shaft PA 2 and a lagging axis SL 2 may become 2beta+45 degree.
[0283] The light which carried out incidence at right angles to the liquid crystal layer 30 in a perpendicular orientation state turns into the linearly polarized light from the TFT substrate 100a side through polarizing plate 50a, and it becomes the linearly polarized light which has the polarization direction of the angle of 2beta to the transparency shaft PA 2 of polarizing plate 50a through lambda/2 board 70a. Incidence of this linearly polarized light is carried out to lambda/4 board 60a, and it is changed into the circular polarization of light. This circular polarization of light passes the liquid crystal layer 30, with a polarization state maintained, and it carries out incidence to lambda/4 board 60b. It is changed into the linearly polarized light which has the polarization direction of the angle of 45 degrees by lambda/4 board 60b to the lagging axis SL 1 of lambda/4 board 60b. Incidence of this linearly polarized light is carried out to lambda/2 board 70b, and it turns into the linearly polarized light of a 2beta+45 degree angle to the lagging axis SL 1 of lambda/4 board 60b, and carries out incidence to polarizing plate 50b. Here, since the polarization direction of the linearly polarized light which passed lambda/2 board 70b lies at right angles to the transparency shaft PA 1 of polarizing plate 50b, this linearly polarized light is absorbed by polarizing plate 50b. Therefore, liquid crystal display 100D will be in a black display state in the state of no voltage impressing.
[0284] In liquid crystal display 100D, since it has lambda/2 board 70a, and lambda/2 board 70b, respectively between lambda/4 board 60a, and polarizing plate 50a and between lambda/4 board 60b, and polarizing plate 50b and lambda/2 boards 70a and 70b ease the wavelength dispersion of the refractive-index anisotropy of lambda/4 boards 60a and 60b, the good black display without coloring is attained.
[0285] In order to suppress further generating of the coloring phenomenon in this black display state The transparency shafts PA2 and PA1 of polarizing plates 50a and 50b are made to intersect perpendicularly mutually like liquid crystal display 100E shown in drawing 47. And the lagging axes SL2 and SL1 of lambda/4 boards 60a and 60b are made to intersect perpendicularly mutually, and the lagging axes SL4 and SL3 of lambda/2 boards 70a and 70b are made to intersect perpendicularly mutually further. Moreover, when setting the angle between the transparency shaft PA 1 of polarizing plate 50b, and the lagging axis SL 3 of lambda/2 board 70b to alpha (degree), It is arranged so that the angle between the transparency shaft PA 1 of polarizing plate 50b and the lagging axis SL 1 of lambda/4 board 60b may serve as 45 degree of 2 ****. The angle between the transparency shaft PA 2 of polarizing plate 50a and the lagging axis SL 4 of lambda/2 board 70a is arranged so that the angle between the transparency shaft PA 2 of alpha and polarizing plate 50a and the lagging axis SL 2 of lambda/4 board 60a may serve as 45 degree of 2 ****. Moreover, this angle between the transparency shaft PA 2 of polarizing plate 50a and the lagging axis SL 2 of lambda/4 board 60a (45 degree of 2 ****) is set up so that the angle (45 degree of 2 ****) and sign between the transparency shaft PA 1 of polarizing plate 50b and the lagging axis SL 1 of lambda/4 board 60b may be in agreement.

[0286] Further [make / intersect perpendicularly mutually, respectively / the transparency shafts of polarizing plates 50a and 50b, the lagging axes of lambda/4 boards 60a and 60b, and / thus, / the lagging axes of lambda/2 boards 70a and 70b] Can offset the wavelength dispersion of the refractive-index anisotropy which each of lambda/4 board 60a, and lambda/4 board 60b has, and it sets in the black display state. The light of the latus wavelength range is absorbed by polarizing plate 50b, and, as for liquid crystal display 100E, a still better black display is realized rather than liquid crystal display 100D.
[0287] Above-mentioned explanation explained the operation of the liquid crystal layer 30 to the light which carries out incidence at right angles to the liquid crystal layer 30. In a liquid crystal display, especially in a penetrated type, although the light which carries out incidence at right angles to the liquid crystal layer 30 contributes to a display most, the light which carries out incidence to the liquid crystal layer 30 aslant also contributes to a display. As for the light which carries out incidence aslant, phase contrast is given to the liquid crystal layer 30 also by the liquid crystal layer 30 of a perpendicular orientation state. Therefore, when the screen of a liquid crystal display is seen from across (direction which inclined from the screen normal), optical leakage may occur in the perpendicular orientation state which should originally be in a black display state, and the contrast ratio of a display may fall.
[0288] By forming further the phase contrast board (viewing-angle compensating plate) which has a refractive-index anisotropy which offsets the phase contrast over this oblique-incidence light, the liquid crystal display which has a good contrast ratio in all the viewing-angle ranges is realizable. In addition, this viewing-angle compensating plate does not need to be a single phase contrast board, and what carried out the laminating of two or more phase contrast boards is sufficient as it. Moreover, the position in which a viewing-angle compensating plate is prepared may establish at least the outside of the outside (furthest side from the liquid crystal layer 30) of TFT substrate 100a, and opposite substrate 100b in the outside of both TFT substrate 100a and opposite substrate 100b.
[0289] In addition, although explanation of the lambda/4 above-mentioned wavelength plate explained the case of a penetrated type liquid crystal display, in order to improve the quality of a display in the reflective mode in a reflected type or a transparency reflective two-ways type liquid crystal display, it needs to reduce the wavelength dispersion of the phase contrast board of lambda/4 board arranged at the observer side of a liquid crystal display. Therefore, it is desirable to use wide band lambda / 4 board. Moreover, in a two-ways type liquid crystal display, as mentioned above about the penetrated type liquid crystal display, wide band lambda / 4 board may be arranged on both sides of a liquid crystal display, and the composition which makes the wavelength dispersion of wide band lambda / 4 board offset mutually may be adopted.
[0290]
[Example] Below, this invention is explained based on an example. this invention is not limited by the following examples. Especially the patterns (a configuration and arrangement) of opening which the upper conductive layer has, and the solid section may be various patterns explained with the operation gestalt 1.
[0291] (Example 1) The cross section of the penetrated type liquid crystal display 800 of an example 1 is shown in drawing 48, and a plan is shown in drawing 49, respectively. Drawing 48 is the cross section which met the 48A-48A' line in drawing 49.
[0292] The penetrated type liquid crystal display 800 is a TFT type liquid crystal display of for example, 3.5 type 180,000 picture elements (the number width of dots 840x length 220, 229 micrometers by [dot pitch] 86 micrometers).
[0293] The liquid crystal display 800 has TFT substrate 800a, opposite substrate 800b, and the perpendicular orientation liquid crystal layer 30 arranged among these. Each of the picture element field arranged in the shape of a matrix is driven with the voltage impressed to the picture element electrode 105 and a counterelectrode 122. the picture element electrode 105 is connected to the source wiring 114 with which a signal level is given through TFT118 -- having -- **** -- TFT118 -- from the gate wiring 108 -- giving -- a ****** scanning signal -- the -- switching control is carried out A signal level is impressed to the picture element electrode 105 connected to TFT118 made into ON state by the scanning signal.
[0294] The picture element electrode 105 has the lower layer conductive layer 102, the upper conductive layer 104, and the dielectric layer (the layer insulation layer 107 and photopolymer layer 103) prepared in these in between. The lower layer conductive layer 102 and the upper conductive layer 104 are mutually connected electrically in contact hole 107a. The upper conductive layer 104 has opening 104a, and generates slanting electric field in the edge section at the time of voltage impression. Opening 104a is formed in one field surrounded by the gate wiring 108, the source wiring 114, and the auxiliary capacity wiring 119. Two opening 104a is formed for every picture element field.
[0295] In addition, the auxiliary capacity wiring 119 is formed so that near the simultaneously center of a picture element field may be prolonged in parallel with the gate wiring 108. The auxiliary capacity wiring 119 forms auxiliary capacity with the lower layer conductive layer 102 which counters through the gate insulating layer 110. Auxiliary

capacity is prepared in order to improve the retention of picture element capacity. Of course, auxiliary capacity may be omitted and the structure of auxiliary capacity is not restricted to the above-mentioned example.
[0296] First, the manufacture method of TFT substrate 800a of a liquid crystal display 800 is explained, referring to drawing 50 A.
[0297] As shown in drawing 50 A (a), the insulating layer (un-illustrating) which consists of Ta2O5, SiO2, etc. as a base coat film is formed on the insulating transparent substrate 101 if needed. Then, the gate electrode (gate wiring is also included) 108 is formed by forming and carrying out patterning of the metal layer which consists of aluminum, Mo, Ta, etc. by the sputtering method. Here, the gate electrode 108 is formed using Ta. At this time, you may form the auxiliary capacity wiring 119 at the same process using the same material.
[0298] Next, the gate insulating layer 110 is formed all over the simultaneously of the front face of a substrate 101 so that the gate electrode 108 may be covered. Here, a SiNx film with a thickness of about 300nm is deposited by P-CVD, and the gate insulating layer 110 is formed. In addition, the gate electrode 108 is anodized and this oxide film on anode can also be used as a gate insulating layer. Of course, it is good also as two-layer structure equipped with an oxide film on anode and insulator layers, such as SiNx.
[0299] On the gate insulating layer 110, Si layer used as the channel layer 111 and the electrode contact layer 112 is continuously deposited in CVD. The amorphous silicon or microcrystal Si layer which doped impurities with a thickness of about 50nm, such as Lynn, is used for the electrode contact layer 112 at the channel layer 111 using an amorphous silicon layer with a thickness of about 150nm. By carrying out patterning of these Si layers by the dry etching method by the mixed gas of HCl+SF6 etc., the channel layer 111 and the electrode contact layer 112 are formed.
[0300] Then, as shown in drawing 50 A (b), about 150nm (ITO) of transparent conductive layers 102 which constitute a lower layer conductive layer is deposited by the sputtering method. Then, the laminating of the metal layers 114 and 115 which consist of aluminum, Mo, Ta, etc. is carried out. Here, Ta is used. By carrying out patterning of these metal layers, the source electrodes 113 and 114 and the drain electrodes 113 and 115 are formed (it is hereafter written as the "source electrode 114" and the "drain electrode 115".). The source electrode 114 and the drain electrode 115 have two-layer structure, respectively, and give the reference mark 113 to the conductive layer which consists of an ITO layer 102. The ITO layer 102 functions as a lower layer conductive layer of the picture element electrode of two-layer structure.
[0301] Next, as shown in drawing 50 A (c), after depositing in CVD about 300nm of insulating layers which consist of SiNx etc., patterning is carried out and the layer insulation layer 107 is formed. Contact hole 107a for connecting electrically the upper conductive layer 103 and the ITO layer 102 which are formed behind in the case of patterning is formed in the layer insulation layer 107 on the auxiliary capacity wiring 119.
[0302] Next, as shown in drawing 50 A (d), opening 103a which exposes the drain electrode 102 in contact hole 107a of the layer insulation layer 107 is fabricated by forming the photopolymer layer 103 used as a dielectric layer on this layer insulation layer 107, and exposing and developing the photopolymer layer 103. The photopolymer layer 103 is formed in the thickness of about 1.5 micrometers for example, using a positive-type photopolymer (acrylic resin : specific inductive capacity 3.7 made from JSR). In addition, the photopolymer layer 103 may be formed using a resin without photosensitivity, and opening 103a may be separately formed in a nonphotosensitivity resin layer at the photolithography process using a photoresist.
[0303] Next, as shown in drawing 50 A (e), the transparent conductive layer (ITO) 104 which constitutes the upper conductive layer is formed by the sputtering method at the thickness of about 100nm on the substrate 101 in which the layer insulation layer 107 and the photopolymer layer 103 were formed.
[0304] Then, TFT substrate 800a shown in drawing 48 is obtained by forming opening 104a in the transparent conductive layer 104. Formation of opening 104a can be performed by the following methods.
[0305] On the transparent conductive layer 104, photoresist material is applied and the photoresist layer of a predetermined pattern is formed in a photo lithography process. Opening 104a is formed by **********ing considering this photoresist layer as a mask. Then, a photoresist layer is exfoliated. Here, rectangular opening 14a is formed for two kinds (a= 68 micrometers, b= 59 micrometers (on [in drawing]), a= 68 micrometers, and b= 36 micrometers (under [in drawing])) as opening 104a of the transparent conductive layer 104.
[0306] Thus, TFT substrate 800a equipped with the picture element electrode of the two-layer structure which consists of a lower layer conductive layer 102 which consists of an ITO layer, an upper conductive layer 104 which consists of an ITO layer, and the layer insulation layer 107 and dielectric layer 103 among these is obtained.
[0307] Here, although the dielectric layer inserted between the upper conductive layer 104 and the lower layer conductive layer 102 is formed by two-layer [of the layer insulation layer 107 and a photopolymer 103], the need does not exist, and you may form it by either, and it may also contain the layer of further others. There is no limit in the

kind of material, thickness, and a number of layers that the dielectric layer prepared between the upper conductive layer and a lower layer conductive layer should just be formed so that the slanting electric field which make a liquid crystal molecule incline in the edge section of opening 104a of the upper conductive layer may be produced. It is desirable to use a high material of transparency so that the use efficiency of light may not fall.

[0308] Other manufacture methods of TFT substrate 800a of a liquid crystal display 800 are explained referring to drawing 50 B.

[0309] As shown in drawing 50 B (a), the insulating layer (un-illustrating) which consists of Ta2O5, SiO2, etc. as a base coat film is formed on the insulating transparent substrate 101 if needed. Then, the gate electrode (gate wiring is also included) 108 is formed by forming and carrying out patterning of the metal layer which consists of A1, Mo, Ta, etc. by the sputtering method. Here, the gate electrode 108 is formed using the cascade screen of Ti/A1/Ti. At this time, you may form the auxiliary capacity wiring 119 at the same process using the same material.

[0310] Next, the gate insulating layer 110 is formed all over the simultaneously of the front face of a substrate 101 so that the gate electrode 108 may be covered. Here, a SiNx film with a thickness of about 300nm is deposited by P-CVD, and the gate insulating layer 110 is formed.

[0311] On the gate insulating layer 110, Si layer used as the channel layer 111 and the electrode contact layer 112 is continuously deposited in CVD. The amorphous silicon or microcrystal Si layer which doped impurities with a thickness of about 50nm, such as Lynn, is used for the electrode contact layer 112 at the channel layer 111 using an amorphous silicon layer with a thickness of about 150nm. By carrying out patterning of these Si layers by the dry etching method by the mixed gas of HCl+SF6 etc., the channel layer 111 and the electrode contact layer 112 are formed.

[0312] Then, as shown in drawing 50 B (b), the laminating of the metal layers 7114 and 115 which consist of A1, Mo, Ta, etc. is carried out. Here, the cascade screen of A1/Ti is used. By carrying out patterning of these metal layers, the source electrode 114 and the drain electrode 115 are formed. Next, it **********s in 112g of gap sections of the electrode contact layer 112 by PATANIGU [using the source electrode 114 and the drain electrode 115 as a mask, and / with the dry etching method by the mixed gas of HCl+SF6 etc.].

[0313] Next, as shown in drawing 50 B (c), after depositing in CVD about 300nm of insulating layers which consist of SiNx etc., patterning is carried out and the layer insulation layer 107 is formed. Contact hole 107a for connecting electrically the lower layer conductive layer 102 and the drain electrode 115 which consist of an ITO layer formed behind in the case of patterning is formed in the layer insulation layer 107 on the auxiliary capacity wiring 119.

[0314] Next, as shown in drawing 50 B (d), the transparent conductive layer (ITO) 102 which constitutes a lower layer conductive layer is formed in the thickness of about 140nm by the sputtering method.

[0315] Next, as shown in drawing 50 B (e), opening 103a to which the lower layer conductive layer 102 which consists of an ITO layer is exposed is fabricated by forming the photopolymer layer 103 used as a dielectric layer on the lower layer conductive layer 102 which consists of this ITO layer, and exposing and developing the photopolymer layer 103. The photopolymer layer 103 is formed in the thickness of about 1.5 micrometers for example, using a positive-type photopolymer (acrylic resin : specific inductive capacity 3.7 made from JSR). In addition, the photopolymer layer 103 may be formed using a resin without photosensitivity, and opening 103a may be separately formed in a nonphotosensitivity resin layer at the photolithography process using a photoresist.

[0316] Next, as shown in drawing 50 B (f), the transparent conductive layer (ITO) 104 which constitutes the upper conductive layer is formed by the sputtering method on the substrate 101 in which the photopolymer layer 103 was formed at the thickness of about 100nm.

[0317] Then, TFT substrate 800a shown in drawing 48 is obtained by forming opening 104a in the transparent conductive layer 104. Formation of opening 104a can be performed by the following methods.

[0318] On the transparent conductive layer 104, photoresist material is applied and the photoresist layer of a predetermined pattern is formed in a photo lithography process. Opening 104a is formed by **********ing considering this resist layer as a mask. Then, a photoresist layer is exfoliated.

[0319] Thus, TFT substrate 800a equipped with the picture element electrode of the two-layer structure which consists of a lower layer conductive layer 102 which consists of an ITO layer, an upper conductive layer 104 which consists of an ITO layer, and the layer insulation layer 107 and dielectric layer 103 among these is obtained.

[0320] If the stable radial inclination orientation is acquired that the dielectric layer prepared between the upper conductive layer and a lower layer conductive layer should just be formed so that the slanting electric field which make a liquid crystal molecule incline in the edge section of opening 104a of the upper conductive layer may be produced, there will be no limit in the kind of material, thickness, and a number of layers. It is desirable to use a high material of transparency so that the use efficiency of light may not fall.

[0321] On the other hand, opposite substrate 800b forms the counterelectrode 122 which uses the sputtering method

and consists of ITO on the insulating transparent substrate 121.

[0322] Perpendicular orientation processing is performed on the inside front face of TFT substrate 800a obtained as mentioned above and opposite substrate 800b. For example, a perpendicular orientation layer is formed using the perpendicular stacking-tendency polyimide made from JSR. Rubbing processing is not performed in a perpendicular orientation layer.

[0323] A spherical plastics bead with a diameter of 3 micrometers is sprinkled on the inside front face of opposite substrate 800b, and opposite substrate 800b and TFT substrate 800a are stuck on it using a well-known sealing compound. Then, for example, the material which added the chiral agent is poured into the nematic-liquid-crystal material (**n=0.0996) which has a negative dielectric anisotropy by Merck Co. Thus, a liquid crystal panel is obtained. In addition, the structural unit which has the substrate (here, they are TFT substrate 800a and opposite substrate 800b) of a couple and the liquid crystal layer pinched among these among the structural units which constitute a liquid crystal display is called a "liquid crystal panel."

[0324] Polarizing plate 50a is arranged on the outside of TFT substrate 800a of the obtained liquid crystal panel, and polarizing plate 50b is arranged on the outside of opposite substrate 800b. The transparency shaft of polarizing plate 50a and polarizing plate 50a is arranged so that it may intersect perpendicularly mutually (refer to drawing 41 (b)). Moreover, it arranges so that the transparency shaft of polarizing plate 50a and polarizing plate 50b may become 45 degrees to the installation direction of gate wiring of a liquid crystal panel, respectively.

[0325] Thus, the liquid crystal display obtained realizes a good black display at the time (the time of impressing the voltage of under threshold voltage is included) of no voltage impressing.

[0326] Moreover, the situation of the picture element field when impressing voltage (voltage more than threshold voltage) to the liquid crystal layer of this liquid crystal display 800 is typically shown in drawing 51. Drawing 51 shows two adjoining picture element fields.

[0327] As shown in drawing 51, the quenching pattern (dark space) centering on the center of opening 104a is looked at by every opening 104a. At the center (curved intersection) of a quenching pattern, a liquid crystal molecule is in a perpendicular orientation state, and radial inclination orientation of the main surrounding liquid crystal molecule is carried out the center [the liquid crystal molecule of a perpendicular orientation state]. This is because slanting electric field were generated by the picture element electrode of the two-layer structure of having opening 104a. That in addition, dark space is observed in the shape of an abbreviation cross in a voltage impression state The polarization direction of the linearly polarized light which carried out incidence to the liquid crystal layer as explained previously, and the direction which is parallel or intersects perpendicularly () That is, the linearly polarized light which passed through the field as for which the liquid crystal molecule is carrying out orientation in the direction which is parallel or intersects perpendicularly with the transparency shaft of polarizing plate 50a is because it is absorbed by polarizing plate 50b and does not contribute to a display, since a liquid crystal layer is passed phase contrast's giving by the liquid crystal layer, and maintaining **** and a polarization state. In this example, since the liquid crystal material by which the chiral agent was added is used, quenching is observed in the position [shaft / absorption / of the polarizing plate which the liquid crystal layer serves as whorl-like radial inclination orientation, consequently intersects perpendicularly mutually] shifted.

[0328] Moreover, the field observed white (bright) in the state of voltage impression is a field where the linearly polarized light which carried out incidence to the liquid crystal layer was able to give phase contrast by the liquid crystal layer, and it depends for the grade of whiteness (luminosity) on the size of the phase contrast given by the liquid crystal layer. Therefore, the orientation state of a liquid crystal layer is changed by controlling the size of the voltage impressed to a liquid crystal layer, and a gradation display is realizable if the size of the phase contrast which ******** gives is adjusted.

[0329] Arrangement of the polarizing plates 50a and 50b of a couple with which a transparency shaft intersects perpendicularly mutually is not restricted to the above-mentioned example, but you may arrange it so that it is parallel or may intersect perpendicularly with gate wiring. Since the liquid crystal layer of the liquid crystal display by this invention is a perpendicular orientation type liquid crystal layer which will be in a radial inclination orientation state at the time of voltage impression, the transparency shaft orientation of a polarizing plate may be set up in the arbitrary directions. According to the use of a liquid crystal display, it is suitably set up in consideration of a viewing-angle property etc. The angle-of-visibility property of the vertical direction of the screen and a longitudinal direction can be improved by setting up the transparency shaft of a polarizing plate in the direction which is parallel or intersects perpendicularly with gate wiring (or source wiring) especially. This of the polarization selectivity of a polarizing plate is the highest in the direction which is parallel or intersects perpendicularly with a transparency shaft, and is because it becomes the lowest in 45 degrees from a transparency shaft. Furthermore, when the transparency shaft of a polarizing plate is set up in the direction which is parallel or intersects perpendicularly with gate wiring, even if the liquid crystal

molecule which exists near the gate wiring by the slanting electric field from gate wiring inclines in the direction which intersects perpendicularly in the installation direction of gate wiring, optical leakage has the advantage of not generating.
[0330] Moreover, if it is the composition incidence of the circular polarization of light is carried out [composition] to a liquid crystal layer by using lambda/4 board, the quenching pattern observed almost in accordance with the transparency shaft of a polarizing plate can be abolished, and the use efficiency of light can be improved. Furthermore, by preparing lambda/2 board and a viewing-angle compensating plate, generating of coloring of a black display can be suppressed and the liquid crystal display which can realize a high-definition display can be obtained.
[0331] The liquid crystal display 800 of this example is the liquid crystal display in perpendicular orientation type normally black mode, and the display of a high contrast ratio is possible for it, and since the liquid crystal layer which carried out radial inclination orientation is used, in all directions, it has the wide-field-of-view angle property. Furthermore, since the slanting electric field formed by the two-layer structure electrode which has opening are used for formation of radial inclination orientation, a controllability is good and can realize good radial inclination orientation.
[0332] Of course, the structure of a picture element electrode is not restricted to the illustrated structure, but the two-layer structure of the various structures where it explained with the previous operation gestalt can be used for it. Furthermore, a reflected type liquid crystal display and a transparency reflective two-ways type liquid crystal display can be obtained by changing the material which forms the upper conductive layer and/or a lower layer conductive layer.
[0333] (Example 2) Compared with the liquid crystal display 800 of an example 1, the picture element electrode of the penetrated type liquid crystal display of an example 2 has much comparatively small openings, and opening covers the whole picture element electrode (the upper conductive layer), and it is formed. It cannot pass over the configuration of opening and the solid section, or arrangement to an example, but they can use the various patterns illustrated with the operation gestalt 1. The pattern shown in drawing 19 (b) from a viewpoint of display brightness is desirable. Moreover, the rate of surface ratio of opening and the solid section is optimized according to the indicator explained while referring to drawing 22.
[0334] Before explaining the structure of the liquid crystal display of an example 2, and operation, the fault which the liquid crystal display 800 of an example 1 may have is explained. In addition, this fault may not pose a problem depending on the use of a liquid crystal display.
[0335] First, since size is comparatively large, after opening 104a (opening:a=68micrometer of the top the especially larger one and in drawing 49, b= 59 micrometers) which the upper conductive layer 104 of a liquid crystal display 800 has impresses voltage to the liquid crystal layer 30, its time until it takes the radial inclination orientation by which the liquid crystal layer 30 located in opening 104a was stabilized is long. Therefore, depending on a use, the problem that a speed of response is slow arises.
[0336] Moreover, like the field between the bottom edge section of opening 104a of the bottom in drawing 49, and the gate wiring 108 (the width of face of a direction parallel to a source line is about 25 micrometers), the liquid crystal layer 30 of a field with a long distance from the edge section of opening 104a will require comparatively long time, before taking stable radial inclination orientation. Moreover, since the liquid crystal layer 30 located in the edge section (for example, near the lower right in drawing 49) of the upper conductive layer 104 which is separated from the edge section of opening 104a is influenced [of the slanting electric field generated by opening 104a and the electric field generated by the signal level currently impressed to the source wiring 114 (113)], the inclination direction of liquid crystal molecule 30a may not be stabilized by it for every pixel. Consequently, a rough deposit may be looked at by display.
[0337] The structure of the liquid crystal display 900 of an example 2 and operation are explained referring to drawing 52 and drawing 53. The cross section of a liquid crystal display 900 is shown in drawing 52, and a plan is shown in drawing 53, respectively. Drawing 52 is the cross section which met the 52A-52A' line in drawing 53. In the following explanation, the same reference mark shows the component of the liquid crystal display 800 of an example 1, and the component which has the same function substantially among the components of a liquid crystal display 900, and the explanation is omitted. A liquid crystal display 900 can be manufactured in the same process as substantially as a liquid crystal display 800.
[0338] As shown in drawing 52, the upper conductive layer 104 of a liquid crystal display 900 has much comparatively small opening 104a in comparison. Here, 23 circular opening 104a is formed every (every upper conductive layer 104) picture element electrode 105. The interval between opening 104a by which the diameter of opening 104a adjoins in a line writing direction or the direction of a train (direction parallel to gate wiring or source wiring) as 20 micrometers supposes that it is fixed by 4 micrometers, respectively. Opening 104a covers the whole picture element electrode 105,

is arranged in the shape of a tetragonal lattice, and it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature. Moreover, the distance of the edge of outside (close to edge of upper conductive layer 104) opening 104a and the edge of the upper conductive layer 104 is setting inside [it is opening 104a] to about 5 micrometers most.

[0339] The liquid crystal layer 30 to which it is located in opening 104a by voltage impression with 20 micrometers since the diameter of opening 104a which the upper conductive layer 104 of a liquid crystal display 900 has is comparatively small takes stable radial inclination orientation promptly. Moreover, opening 104a is arranged in the shape of a tetragonal lattice, and since it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature, radial inclination orientation also with the stable liquid crystal layer 30 located between opening 104a is taken. Furthermore, 4 micrometers and the liquid crystal layer 30 located among opening 104a since it is comparatively short also carry out orientation change of the distance between adjoining opening 104a promptly. Moreover, the field by which the inclination direction of a liquid crystal molecule is not stabilized can be narrowed [near the edge section of the upper conductive layer 104] by arranging opening 104a also near the edge section of the upper conductive layer 104 (about 5 micrometers).

[0340] The liquid crystal display 900 of this example had the quick speed of response compared with the liquid crystal display 800, and it actually checked that the rough deposit of a display was not seen.

[0341] If the composition which prepares two or more opening 104a every picture element electrode 105 is adopted as mentioned above, it becomes possible to optimize the size of opening 104a, and arrangement, and the liquid crystal display whose stability (repeatability is included) of a speed of response or radial inclination orientation improved can be obtained.

[0342] In the penetrated type liquid crystal displays 800 and 900 of the examples 1 and 2 mentioned above, the voltage impressed to the liquid crystal layer 30 located on opening 104a of the upper conductive layer 104 is influenced of the voltage drop by the photopolymer layer 103. Therefore, the voltage impressed to the liquid crystal layer 30 located on opening 104a becomes lower than the voltage impressed to the liquid crystal layer 30 located on the upper conductive layer 104 (field except opening 104a). Therefore, if the same voltage (signal level) as the upper conductive layer 104 and the lower layer conductive layer 102 is impressed, a voltage-permeability property will change with places in a picture element field, and the permeability of the liquid crystal layer 30 located on opening 104a will become low relatively. Since it displays in normally black mode, although there is nothing that black level floats (the permeability at the time of no voltage impressing rises), liquid crystal displays 800 and 900 need to impress voltage higher than usual to a liquid crystal layer, in order to realize sufficient white level (brightest display state when actually using).

[0343] What is necessary is just to form a crevice or a hole in the photopolymer layer 103 located in opening 104a, as explained referring to drawing 34 and drawing 35 in order to suppress the voltage drop by the photopolymer layer 103 of the voltage impressed to the liquid crystal layer 30 located in opening 104a. In the examples 1 and 2, since the photopolymer is used, a crevice or a hole can be formed in a well-known photolithography process.

[0344] If a crevice or a hole is formed in the photopolymer layer 103 located in opening 104a, while being able to reduce the voltage drop by the photopolymer layer 103 of the voltage impressed to the liquid crystal layer 30 located in opening 104a, decline in the permeability by the photopolymer layer 103 can be reduced, and the use efficiency of light can be improved. Moreover, if thickness of the photopolymer layer 103 in opening 103a is made thin, since the liquid crystal layer 30 thickness on opening 104a will become thick, namely, a retardation will become large compared with the thickness of the liquid crystal layer 30 on the upper conductive layers 104 other than opening 104a, permeability (efficiency for light utilization) improves.

[0345] (Example 3) The cross section of the transparency reflective two-ways type liquid crystal display 1000 of an example 3 is shown in drawing 54, and a plan is shown in drawing 55, respectively. Drawing 54 is the cross section which met the 54A-54A' line in drawing 55. In the following explanation, the same reference mark shows the component of the liquid crystal display 800 of an example 1, and the component which has the same function substantially among the components of a liquid crystal display 1000, and the explanation is omitted.

[0346] The liquid crystal display 1000 has TFT substrate 1000a, opposite substrate 800b, and the perpendicular orientation liquid crystal layer 30 arranged among these. Each of the picture element field arranged in the shape of a matrix is driven with the voltage impressed to the picture element electrode 105 and a counterelectrode 122. The picture element electrode 105 is connected to the source wiring 114 through TFT118. TFT118 is given from the gate wiring 108, and the switching is controlled by the ****** scanning signal. A signal level is impressed to the picture element electrode 105 connected to TFT118 made into ON state by the scanning signal.

[0347] The picture element electrode 105 has transparence lower layer conductive-layer 102T which function as a transparent electrode, reflective upper conductive-layer 104R which functions as a reflector, and the dielectric layer (the layer insulation layer 107 and photopolymer layer 103) prepared among these. Transparence lower layer

conductive-layer 102T and reflective upper conductive-layer 104R are mutually connected electrically in contact hole 107a. Reflective upper conductive-layer 104R has opening 104a, and generates slanting electric field in the edge section at the time of voltage impression. The photopolymer layer 103 has opening 103a formed so that it might correspond to opening 104a. Transparence lower layer conductive-layer 102T are exposed in opening 103a. Eight opening 104a and opening 103a are formed for every picture element field.
[0348] A liquid crystal display 1000 can be manufactured as follows. Explanation of the same process as the manufacture method of a liquid crystal display 800 is omitted.
[0349] The application process of the photopolymer layer 103 can form TFT substrate 1000a at the same process as TFT substrate 800a (refer to drawing 50 A(a) - (c)).
[0350] Next, as shown in drawing 56 (a), a photopolymer is applied on the layer insulation layer 107. For example, it applies to the thickness of about about 3.7 micrometers, using the photopolymer (acrylic resin made from JSR) of a positive type as a photopolymer. In addition, this thickness is set up so that it may become the thickness of about 3 micrometers after postbake process completion.
[0351] In this exposure process, a photopolymer 103 is exposed using the photo mask (for example, refer to drawing 40) which has a predetermined pattern for forming two or more smooth concavo-convex sections in the front face of the photopolymer layer 103 (for example, light exposure about 50 mJ(s)).
[0352] By developing the exposed photopolymer layer 103, the irregularity (un-illustrating) of contact hole 107a, opening 103a, and a front face is formed. Moreover, irregularity formed in the front face of the photopolymer layer 103 can be smoothed by heat-treating if needed.
[0353] Next, as shown in drawing 56 (b), the Mo layer 104R1 of a substrate 101 which turns into the upper conductive layer mostly on the whole surface, and the aluminum layer 104R2 are formed in this order by the sputtering method at the thickness of about 100nm, respectively.
[0354] Then, **** and opening 104a are formed in processing into a predetermined pattern reflective upper conductive-layer 104R which consists of a 104R2/Mo layer 104R1 of aluminum layers using a photo lithography process. Opening 104a can be carried out in the example 1 by the method which gave intermediary explanation.
[0355] Moreover, although the dielectric layer inserted between the upper conductive layer 104 and the lower layer conductive layer 113 is formed by the layer insulation layer 107 and two-layer [of a photopolymer 103] here, it is the same as an example 1 that you may form by one layer of either, and may form by the multilayer more than two-layer.
[0356] Next, perpendicular orientation processing is performed on the inside front face of opposite substrate 800b produced according to TFT substrate 800a and the conventional method which were obtained as mentioned above. For example, a perpendicular orientation layer is formed using the perpendicular stacking-tendency polyimide made from JSR. Rubbing processing is not performed in a perpendicular orientation layer.
[0357] A spherical plastics bead with a diameter of 3.0 micrometers is sprinkled on the inside front face of opposite substrate 800b, and opposite substrate 800b and TFT substrate 1000a are stuck on it using a well-known sealing compound. Then, for example, the nematic-liquid-crystal material (**n=0.0649) which has a negative dielectric anisotropy by Merck Co. is poured in. Thus, a liquid crystal panel is obtained.
[0358] The thickness of the liquid crystal layer 30 of the reflective field (on reflective upper conductive-layer 104R) of the obtained liquid crystal panel is set to 3 micrometers of the diameter of a plastics bead, and becomes about 6 micrometers which added about 3 micrometers in thickness of the photopolymer layer 103 after 3 micrometers and the postbake of the diameter of a plastics bead in a transparency field (field corresponding to opening 104a). thus, the retardation (rate of liquid crystal thickness dx birefringence **n) to the light used for a display by adjusting the thickness of the photopolymer layer 103 -- a transparency field and a reflective field -- about -- it becomes possible to make it do one and the use efficiency of light improves
[0359] To the obtained liquid crystal panel, as shown in drawing 43 (a) and (b), the polarizing plates 50a and 50b of a couple and lambda/4 boards 60a and 60b of a couple are arranged. Since the display action by the transparent mode was explained previously, here explains the display action by the reflective mode in the reflective field of a liquid crystal display 1000.
[0360] First, the display action at the time of no voltage impressing is explained. The light which carries out incidence to a reflective field at right angles to opposite substrate 800b from the opposite substrate 800b side turns into the linearly polarized light through polarizing plate 50b, and carries out incidence to lambda/4 board 60b. After being changed into the circular polarization of light by lambda/4 board 60b, incidence is carried out to the liquid crystal layer 30. It is reflected on the front face of reflective upper conductive-layer 104R, and the circular polarization of light which passed the liquid crystal layer 30 and reached reflective upper conductive-layer 104R turns into the circular polarization of light of the circumference of reverse, passes the liquid crystal layer 30 again, and it carries out incidence to lambda/4 board 60b. By lambda/4 board 60b, this circular polarization of light turns into the linearly

polarized light which has the polarization direction of a direction 45 degrees to the lagging axis SL 1 of lambda/4 board 60b, and carries out incidence to polarizing plate 50b. Since the transparency shaft PA 1 of polarizing plate 50b and the polarization shaft of the linearly polarized light which passed lambda/4 board 60b lie at right angles, this linearly polarized light is absorbed by polarizing plate 50b. Therefore, the reflective field of a liquid crystal display 1000 will be in a black display state in the state of no voltage impressing like a transparency field.
[0361] Next, the display action of a voltage impression state is explained.
[0362] Since offered liquid crystal molecule 30a which carried out perpendicular orientation to the substrate front face among the liquid crystal layers 30 which are in a radial inclination orientation state in a voltage impression state does not give phase contrast to the circular polarization of light, this field will be in a black display state. While passing the liquid crystal layer 30 twice, by the liquid crystal layer 30, phase contrast is given and incidence of the circular polarization of light which carried out incidence to the field (fields other than a perpendicular orientation field) of others of the liquid crystal layer 30 is carried out to lambda/4 board 60b. Since the polarization state of the light which carries out incidence to lambda/4 board 60b has shifted from the circular polarization of light state, a part of light which passed lambda/4 board 60b penetrates polarizing plate 50b. Since it is dependent on the size of the phase contrast given by the liquid crystal layer 30, the amount of this polarization to penetrate may be adjusted by controlling the voltage impressed to the liquid crystal layer 30. Therefore, also in a reflective field, a gradation display is attained by controlling the voltage impressed to the liquid crystal layer 30.
[0363] Arrangement of a polarizing plate or a phase contrast board is not restricted to the above-mentioned example, but as explained referring to drawing 41 - drawing 47, it may prepare further lambda/2 board, a viewing-angle compensating plate, etc.
[0364] When it constitutes a two-ways type liquid crystal display using the liquid crystal display by this invention, the configuration of opening 104a, a size, a number, and arrangement are restricted by the display property (surface ratio of a transparency field and a reflective field) for which it asks in order to acquire radial inclination orientation.
[0365] For example, it is necessary to enlarge surface ratio which reflective upper conductive-layer 104R other than opening 104a occupies in a two-ways type liquid crystal display which thinks using the reflected light as important. It becomes difficult about opening 104a of sufficient size to carry out radial inclination orientation of the liquid crystal layer 30 of a reflective field (on reflective upper conductive-layer 104R) stably, when [sufficient] number formation cannot be carried out. That is, the azimuth of the inclination direction of the molecule shaft of liquid crystal molecule 30a at the time of voltage impression is not stabilized (the direction of orientation within the substrate side of liquid crystal molecule 30a seen from the substrate normal does not become a radial, but changes with places). Therefore, the orientation state within the substrate side of the molecule shaft of liquid crystal molecule 30a changes more often with picture element fields.
[0366] Here, the display action when carrying out voltage impression is explained to the liquid crystal layer 30 in the reflective field of a liquid crystal display 1000, referring to drawing 57. Drawing 57 shows typically the field where the inclination directions (azimuth) of liquid crystal molecule 30a differ 180 degrees.
[0367] The phase contrast which will be given from liquid crystal molecule 30a by the time it is reflected by reflective upper conductive-layer 104R and outgoing radiation of the light which carried out incidence to liquid crystal molecule of two right and left from which inclination direction differs 30a is carried out to an observer side, as shown in drawing 57 is the same. Dispersion in the direction of an azimuth of the direction of orientation in the liquid crystal layer of the reflective field which displays in reflective mode is hard to be checked by looking as a rough deposit of a display like [in the case of the transparent mode] so that he can understand from this.
(Example 4) The cross section of the transparency reflective two-ways type liquid crystal display 1100 of an example 4 is shown in drawing 58. Since it is substantially the same, the plan of the two-ways type liquid crystal display 1100 is abbreviated to drawing 55. Drawing 58 is equivalent to the cross section which met the 54A-54A' line in drawing 55.
[0368] In the following explanation, the same reference mark shows the component of the liquid crystal display 1000 of an example 3, and the component which has the same function substantially among the components of a liquid crystal display 1100, and the explanation is omitted. A liquid crystal display 1100 can be manufactured in the same process as substantially as a liquid crystal display 1000.
[0369] A liquid crystal display 1100 differs from the two-ways type liquid crystal display 1000 of an example 3 in the point that the photopolymer layer 103 has crevice 103b. Crevice 103b of the photopolymer layer 103 can be formed as follows, for example.
[0370] What is necessary is just to expose the photopolymer (acrylic resin made from JSR) of the positive type applied to the thickness (about 3 micrometers in thickness after a postbake) of about 3.7 micrometers in the manufacturing process of the liquid crystal display 1000 explained while referring to drawing 56, so that it may leave a part of photopolymer 103 (about 1 micrometer in for example, thickness) in opening 104a (transparency field) (for example,

light exposure about 100 mJ(s)). By passing through a next development process, crevice 103b of the predetermined depth (here about 2 micrometers) is formed.
[0371] Hereafter, the liquid crystal panel of a liquid crystal display 1100 as well as the liquid crystal display 1000 of an example 3 is obtained. Here, a setup and liquid crystal material of a cell gap are made the same as an example 3.
[0372] The thickness of the liquid crystal layer 30 of the reflective field (on reflective upper conductive-layer 104R) of the obtained liquid crystal panel is set to about 5 micrometers which turned into 3 micrometers of the diameter of a plastics bead, and added about 3 micrometers in thickness of the photopolymer layer 103 after 3 micrometers and the postbake of the diameter of a plastics bead in the transparency field (field corresponding to opening 104a), and lengthened 1 micrometer of residual membrane **** of the photopolymer layer 103 in opening 104a. thus, the retardation (rate of liquid crystal thickness dx birefringence **n) to the light used for a display by adjusting the thickness of the photopolymer layer 103 -- a transparency field and a reflective field -- about -- it becomes possible to make it do one and the use efficiency of light improves
[0373] Next, the structure of the edge section of opening 103a of the photopolymer layer 103 in the liquid crystal display 1000 of an example 3 and crevice 103b of the photopolymer layer 103 in the liquid crystal display 1100 of an example 4 is explained, referring to drawing 59 (a) and (b).
[0374] As shown in drawing 59 (a), in the edge section of opening 103a of the photopolymer layer 103, it is changing gradually, carrying out thickness change which followed the field which does not exist from the field where a photopolymer exists. That is, the side of opening 103a has become taper-like. It is based on the sensitization property and development property of a photopolymer that the side of opening 103a becomes taper-like.
[0375] In the edge section of opening 103a in an example 3, as shown in drawing 59 (a), the taper-like side in which the taper angle theta is about 45 degrees is formed. If a perpendicular orientation layer (un-illustrating) is formed in this taper-like side, liquid crystal molecule 30a tends to carry out orientation perpendicularly to the taper-like side. Therefore, liquid crystal molecule 30a on the taper-like side is in the state where it inclined from the perpendicular direction (substrate normal) on the surface of the substrate at the time of no voltage impressing, as [illustrated]. If a taper angle is large, with the inclination direction by the slanting electric field generated at the time of voltage impression, liquid crystal molecule 30a on the taper-like side will incline to the opposite direction, and will become the cause that radial inclination orientation is confused.
[0376] On the other hand, as crevice 103b in an example 4 showed to drawing 59 (b), by leaving a part of photopolymer layer 103 in opening 104a Since a photopolymer 103 exists between the liquid crystal layer 30 in opening 104a, and lower layer conductive-layer 102T while being able to make the taper angle theta of the taper-like side small, the radial inclination orientation by which slanting electric field acted effectively and were stabilized in the liquid crystal layer 30 at the time of voltage impression is acquired. Consequently, the liquid crystal display which has good display grace without a rough deposit is obtained.
[0377] (Example 5) As for the picture element electrode of the penetrated type liquid crystal display of an example 5, unlike the penetrated type liquid crystal display 900 of an example 2, opening is formed also in the edge section of a picture element electrode (the upper conductive layer). Since the liquid crystal display of an example 5 has the same composition substantially with the liquid crystal display of an example 2 except that arrangement of opening which the upper conductive layer 104 has differs, it omits explanation of common structure here.
[0378] Before explaining the structure of the liquid crystal display of an example 5, and operation, the fault which the liquid crystal display 900 of an example 2 may have is explained. In addition, this fault may not pose a problem depending on the use of a liquid crystal display.
[0379] A part of upper conductive layer 104 of the liquid crystal display 900 of an example 2 is typically shown in drawing 60. While the upper conductive layer 104 has much comparatively small opening 104a comparatively, opening 104a covers the whole picture element electrode 105, is arranged in the shape of a tetragonal lattice, and it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature.
[0380] If voltage is impressed to the liquid crystal layer 30, the liquid crystal layer 30 located in circular opening 104a (field A) which the upper conductive layer 104 has will take the stable radial inclination orientation centering on the center SA of opening 104a promptly. Moreover, the liquid crystal layer 30 of the field surrounded by four openings (2x2) 104a located in the lattice point as shown in the field B of drawing 60 takes the stable radial inclination orientation centering on the intersection SA of the diagonal line of the square surrounded by the lattice point by impression of voltage.
[0381] However, the liquid crystal layer 30 of the opening 104a as shown in the field C of drawing 60 most located between the edges of outside (close to edge of upper conductive layer 104) opening 104a, and the upper conductive layer 104 Compared with the field surrounded by the four lattice points shown in the field B of drawing 60, the orientation state by which the symmetric property of the slanting electric field generated by the edge section of the

upper conductive layer 104 and the slanting electric field generated by the edge section of opening 104a was stabilized for the low (direction [of electric field] and symmetric property of strong distribution) reason is not acquired. Consequently, the rough deposit of a display, an after-image, etc. are checked by looking and display grace may fall.
[0382] Although the above-mentioned fault is solvable to some extent by arranging opening 104a near the edge of the upper conductive layer 104 (about 5 micrometers) like the liquid crystal display 900 of an example 2, and narrowing the field (field C) by which the inclination direction of a liquid crystal molecule near the edge section of the upper conductive layer 104 is not stabilized, as long as the field is used as a viewing area, it has a certain bad influence to display grace.
[0383] When it brings close also to remainder and opening 104a is formed in the edge of the upper conductive layer 104, it becomes impossible moreover, to take the radial inclination orientation by which the liquid crystal layer 30 in opening 104a was stabilized under the influence of the slanting electric field of the edge section of the upper conductive layer 104. Therefore, there is a limitation also in narrowing the field (field C) by which the inclination direction of the liquid crystal molecule near the edge of the upper conductive layer 104 is not stabilized. Although it is also one solution to shade the field by which the inclination direction of the liquid crystal molecule shown in the field C of drawing 60 is not stabilized here, since it is accompanied by decline in a numerical aperture, it is not desirable.
[0384] On the other hand, the upper conductive layer 104 of the liquid crystal display of an example 5 has opening 104a' on the edge (the side and angle) of the upper conductive layer 104, as typically shown in drawing 61, drawing 62, and drawing 63. Below, the structure of the upper conductive layer 104 of an example 5 and operation of the liquid crystal molecule when impressing voltage to the liquid crystal layer 30 are explained, referring to these drawings. In addition, the edge of the upper conductive layer 104 is prescribed by the extent (configuration which connects the outside side in a straight line most, and is acquired) of the upper conductive layer 104, and the solid line shows it by drawing 61, drawing 62, and drawing 63.
[0385] As shown in drawing 61, drawing 62, and drawing 63, the upper conductive layer 104 of the liquid crystal display of an example 5 has opening 104a' on the edge. Each of opening 104a prepared in addition to the edge has the configuration (here, circular) which has symmetry-of-revolution nature preferably, and each size is mutually equal. moreover, the center (position of a symmetry axis of rotation inversion) of two or more opening 104a is arranged so that it may have symmetry-of-revolution nature (it illustrated typically -- as -- the shape of a tetragonal lattice) Moreover, it is equivalent to what has arranged the center of opening 104a on the edge of the upper conductive layer 104, and, unlike opening 104a, the configuration which has symmetry-of-revolution nature does not become, but opening 104a' formed in the edge has the configuration where the part was missing. For example, when circular, opening 104a becomes a semicircle as the center showed the configuration of opening 104a' located in the side of the upper conductive layer 104 to drawing 61. Moreover, the configuration of opening 104a' where a center is located in the angle (angle : 90 degrees) of the upper conductive layer 104 serves as a quadrant circle, as shown in drawing 62. Furthermore, when it has the configuration where the upper conductive layer 104 cut and lacked rectangular [a part of], opening 104a' located in the angle (angle : 270 degrees) of the notching section changes to 3/4 yen as [showed / in drawing 63].
[0386] thus -- the upper layer -- a conductive layer -- 104 -- an edge -- preparing -- having had -- opening -- 104 -- a -- ' -- a configuration -- the symmetry of revolution -- a sex -- having -- a configuration -- a part -- having been missing -- a configuration -- it is -- since -- a tetragonal lattice -- four -- a ** -- the lattice point -- a top -- a center -- having -- four -- a ** -- opening -- 104 -- a -- inside -- at least -- one -- a ** -- an edge -- preparing -- having However, if the tetragonal lattice (square) which the center of opening 104a and opening 104a' forms is observed, the corner of each square is occupied with each four quadrant circle of opening 104a and opening 104a', and these four quadrant circles of opening 104a and opening 104a' are arranged so that it may have symmetry-of-revolution nature.
[0387] here, if it thinks on the basis of the portion (this will be called "sub opening".) of the quadrant circle of opening 104a located in the corner of each square, and opening 104a', all the fields specified with the edge of the upper conductive layer 104 will be prescribed by sub opening -- it will be mutually divided into the field of the square of equivalent a large number Moreover, four sub openings which adjoin mutually form opening 104a of a configuration (here, circular) which has one symmetry-of-revolution nature. In addition, opening (3/4 yen, semicircle, or 1/4 yen) 104a' of the configuration where a part of configuration (circular) which has symmetry-of-revolution nature lacked in it since three adjoining sub openings did not exist in sub opening which specifies the field of a square including the side of the upper conductive layer 104 is formed.
[0388] namely, -- having mentioned above -- as -- opening -- 104 -- a -- and -- 104 -- a -- ' -- arranging -- if -- the upper layer -- a conductive layer -- 104 -- an edge -- specifying -- having -- a field (typically, it corresponds to a pixel) -- inside -- an edge -- being located -- opening -- 104 -- a -- ' -- corresponding -- a field -- symmetric property -- a low -- a configuration -- becoming -- although -- others -- a field -- the symmetry of revolution -- a sex -- having --

[0389] Therefore, if voltage is impressed to the liquid crystal layer 30 of the liquid crystal display equipped with the upper conductive layer 104 which has arranged opening 104a and 104a' as mentioned above Not only in the field B surrounded by the field A in opening 104a, and opening 104a The liquid crystal layer 30 of the field C (field including the side of the upper conductive layer 104 (an angle is not included)) surrounded by opening 104a and opening 104a' and Field D (field including the angle of the upper conductive layer 104) takes radial inclination orientation. Consequently, in the liquid crystal display of this example 5, in the liquid crystal display 900 of an example 2, a twist also becomes large and, as for the area of the field which takes radial inclination orientation at the time of voltage impression, can realize the high-definition display without a rough deposit, an after-image, etc.

[0390] In addition, in drawing 61, drawing 62, and drawing 63, although the configuration of opening 104a' formed in the edge of the upper conductive layer 104 was made into 3/4 of opening 104a, 1/2, or the quadrant, as illustrated, it cannot necessarily arrange opening 104a' depending on the size of a pixel pitch and the upper conductive layer 104. In such a case, as long as it takes radial inclination orientation with the stable liquid crystal layer 30 of the edge section of the upper conductive layer 104 at the time of voltage impression, the configuration of opening 104a' formed in the edge of the upper conductive layer 104 may not be 3/4 of opening 104a, 1/2, or a quadrant, may shift the center of opening 104a' from the position which has the symmetry of revolution, and may be arranged.

[0391] Furthermore, it is not necessary to form opening 104a' in all the sides of the upper conductive layer 104, and angles. On the side and the angle of the upper conductive layer 104 located on components, such as bus wiring (signal wiring and scanning wiring) which does not penetrate light especially, even if it does not form opening 104a', the display grace of the liquid crystal display 900 of an example 2 can be improved sharply.

[0392] Moreover, as explained referring to drawing 34 and drawing 35 in order to suppress the voltage drop by the photopolymer layer 103 of the voltage impressed to the liquid crystal layer 30 located in opening 104a like the penetrated type liquid crystal display of examples 1 and 2, you may form a crevice or a hole in the photopolymer layer 103 located in a part of opening 104a.

[0393] In this example, although the penetrated type liquid crystal display was illustrated, of course, arrangement of opening 104a mentioned above and 104a' is applicable to a transparency reflective two-ways type liquid crystal display. In this case, like the transparency reflective two-ways type liquid crystal display of examples 3 and 4, in order to suppress the voltage drop by the photopolymer layer 103, you may form a crevice or a hole in the photopolymer layer 103 located in a part of opening 104a.

[0394] (Example 6) The picture element electrode (the upper conductive layer) of the penetrated type liquid crystal display of an example 6 has opening 104a of arrangement which is different in an example 5, and is stabilizing the radial inclination orientation of the liquid crystal layer 30 of the edge section of the upper conductive layer. Since the liquid crystal display of an example 6 has the same composition substantially with the liquid crystal display of an example 2 and an example 5 except that arrangement of opening which the upper conductive layer 104 has differs, it omits explanation of common structure here.

[0395] A part of upper conductive layer 104 of the liquid crystal display of an example 6 is shown in drawing 64. Operation of the liquid crystal molecule at the time of voltage impression is explained to the structure and the liquid crystal layer 30 of the upper conductive layer 104 of an example 6, referring to drawing 64. As shown in drawing 64, opening 104a which the upper conductive layer 104 has is arranged in the shape of a tetragonal lattice, and it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature. Furthermore, such opening 104a is arranged so that opening 104a near the edge of the upper conductive layer 104 among this opening 104a may form virtual opening 104a" (it does not exist in fact) and the tetragonal lattice which were prepared in the outside of the upper conductive layer 104 and the edge of virtual opening 104a" may lap with the edge of the upper conductive layer 104.

[0396] That is, when it considers that the field in which the conductive layer of the outside of the upper conductive layer 104 is not formed is opening, opening 104a is arranged so that the relative configuration (here tetragonal lattice) which has symmetry-of-revolution nature with opening 104a currently formed in the upper conductive layer 104 may be constituted. The difference from arrangement of opening (104a and 104a' is included) in an example 5 is the point that all the openings formed in the upper conductive layer 104 have the same configuration (configuration which has symmetry-of-revolution nature preferably (here, circular)).

[0397] If voltage is impressed to the liquid crystal layer 30 of the liquid crystal display which besides has the layer conductive layer 104, the liquid crystal layer 30 located in opening 104a (field A) which the upper conductive layer 104 has will take stable radial inclination orientation promptly. Moreover, opening 104a is arranged in the shape of a tetragonal lattice, and since it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature, radial inclination orientation also with the stable liquid crystal layer 30 located between opening 104a (field B) is taken. Furthermore, in the field C near the edge section of the upper conductive

layer 104 (field including the side of the upper conductive layer 104), it is located in three openings 104a located in the lattice point, and the lattice point corresponding to it, and the liquid crystal layer 30 takes stable radial inclination orientation by virtual opening 104a" (field without a conductive layer) with which the edge and edge of the upper conductive layer 104 lap. Moreover, in the field D including the angle of the upper conductive layer 104, it is located in two openings 104a in the position near the angle of the upper conductive layer 104, and the lattice point corresponding to it, and the liquid crystal layer 30 takes stable radial inclination orientation by two virtual opening 104a" (field without a conductive layer) with which the edge and edge of the upper conductive layer 104 lap.

[0398] In addition, depending on the size of a pixel pitch and the upper conductive layer 104, although opening 104a is formed so that the edge of virtual opening 104a" located in the side of the upper conductive layer 104 at the lattice point may lap in drawing 64, as illustrated, opening 104a cannot necessarily be arranged. In such a case, as long as it takes radial inclination orientation with the stable liquid crystal layer 30 of the edge section of the upper conductive layer 104 at the time of voltage impression, you may form opening 104a so that a tetragonal lattice may be formed in the position where the edge of virtual opening 104a" shifted from the edge of the upper conductive layer 104.

[0399] Another example of arrangement is indicated to be drawing 64 to drawing 65. The upper conductive layer 104 shown in drawing 65 is formed so that virtual opening 104a" located in the lattice point may lap with the edge of the upper conductive layer 104 like the upper conductive layer 104 of drawing 64. However, in drawing 64, opening 104a' near the edge of the upper conductive layer 104 has the configuration where a part of other opening 104a was missing, in drawing 65 to having had the configuration in which opening 104a near the edge of the upper conductive layer 104 has symmetry-of-revolution nature like other opening 104a. in addition -- opening -- 104 -- a -- a part -- having been missing -- a configuration -- having -- this -- opening -- 104 -- a -- ' -- an example -- five -- the upper layer -- a conductive layer -- 104 -- having -- opening -- 104 -- a -- ' (for example, refer to drawing 61) -- differing -- the -- a center -- the upper layer -- a conductive layer -- 104 -- an edge -- the inside -- being located -- **** .

[0400] The liquid crystal layer 30 of the edge section (Field C and Field D) of the upper conductive layer 104 takes the stable radial inclination orientation at the time of voltage impression the same with having mentioned above, while referring to drawing 64, even if it had arranged opening 104a and 104a', as shown in drawing 65. Moreover, the same with having mentioned above, as long as it takes radial inclination orientation with the stable liquid crystal layer 30 of the edge section of the upper conductive layer 104 at the time of voltage impression, you may form opening 104a so that a tetragonal lattice may be formed in the position where the edge of virtual opening 104a" shifted from the edge of the upper conductive layer 104.

[0401] (Example 7) Unlike the penetrated type liquid crystal display 900 of an example 2, the penetrated type liquid crystal display 1200 of an example 7 is formed in the lattice point of the tetragonal lattice which the array of two or more opening 104a forms [contact hole 117a for connecting electrically the upper conductive layer 103 and the lower layer conductive layer 102].

[0402] Before explaining the structure of the liquid crystal display 1200 of an example 7, and operation, the fault which the liquid crystal display 900 of an example 2 may have is explained. In addition, this fault may not pose a problem depending on the use of a liquid crystal display.

[0403] As shown in drawing 53, in comparison, much comparatively small opening 104a covers the whole picture element electrode 105, and the upper conductive layer 104 of the liquid crystal display 900 of an example 2 is arranged in the shape of a tetragonal lattice, and it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature. Therefore, if voltage is impressed to the liquid crystal layer 30, the liquid crystal layer 30 located in opening 104a which the upper conductive layer 104 has will take stable radial inclination orientation promptly. Moreover, in the field surrounded by four openings (2x2) 104a located in the lattice point, if voltage is impressed to the liquid crystal layer 30, the stable radial inclination orientation which has a center in the intersection of the diagonal line of the square surrounded by the lattice point will be acquired.

[0404] However, if opening 104a is formed so that it may lap with contact hole 107a, since electrical installation of the lower layer conductive layer 102 and the upper conductive layer 104 cannot be performed in the portion, it is difficult for the upper conductive layer 104 of the periphery of contact hole 107a to arrange opening 104a in the shape of a tetragonal lattice. Therefore, the orientation state by which the symmetric property (the direction of electric field and symmetric property of a strong distribution) of slanting electric field was stabilized for the low reason is not acquired around contact hole 107a. Consequently, a rough deposit, an after-image, etc. of a display are checked by looking and display grace may fall.

[0405] Although this fault is forming contact hole 107a on the field where the back light light of auxiliary capacity wiring 119 grade is shaded like an example 2 and it can solve to some extent by being hardly visible and carrying out the field by which the inclination direction of a liquid crystal molecule is not stabilized in the circumference of contact hole 107a, the field has a certain bad influence to display grace, as long as a part also exists in the light-transmission

section. here, although it is also one solution to shade completely the field by which the inclination direction of the liquid crystal molecule of the contact hole 107a circumference of drawing 53 is not stabilized, it is accompanied by decline in a numerical aperture -- it is not desirable

[0406] on the other hand, the liquid crystal display 1200 of an example 7 -- drawing 66 and drawing 67 -- ****** -- while opening 104a covers the whole picture element electrode 105 and is arranged in the shape of a tetragonal lattice like, contact hole 117a is formed in the position of the lattice point of the tetragonal lattice The structure of the liquid crystal display 1200 of an example 7 and operation are explained referring to these drawings. In addition, in the following explanation, the same reference mark shows the component of the liquid crystal display 900 of an example 2, and the component which has the same function substantially among the components of a liquid crystal display 1200, and the explanation is omitted. Moreover, a liquid crystal display 1200 can be manufactured in the same process as substantially as a liquid crystal display 900.

[0407] As shown in drawing 66 and drawing 67, while opening 104a covers the whole picture element electrode 105 and being arranged in the shape of a tetragonal lattice, contact hole 117a is formed in the position of the lattice point. Moreover, opening 104a of the upper conductive layer 104 is formed also in the field which the back light light on the auxiliary capacity wiring 119 does not penetrate at the lattice point. Therefore, if voltage is impressed to the liquid crystal layer 30, the liquid crystal layer 30 located in opening 104a which the upper conductive layer 104 has will take stable radial inclination orientation promptly. The liquid crystal layer 30 located on contact hole 117a also takes stable radial inclination orientation promptly. This is because contact hole 117a functions as crevice 103b formed in the photopolymer layer 103 in the transparency reflective two-ways type liquid crystal display 1100 of the example 4 shown in drawing 58 similarly.

[0408] Moreover, opening 104a is arranged in the shape of a tetragonal lattice, and since it is arranged so that four openings (2x2) 104a located in the lattice point may have symmetry-of-revolution nature, radial inclination orientation also with the stable liquid crystal layer 30 located between opening 104a is taken. Furthermore, contact hole 117a and opening 104a are arranged in the shape of a tetragonal lattice, and since it is arranged so that four openings (2x2) 104a and contact hole 117a which are located in the lattice point may have symmetry-of-revolution nature, radial inclination orientation also with the stable liquid crystal layer 30 near the contact hole 117a located between contact hole 117a and opening 104a is taken.

[0409] As mentioned above, in the liquid crystal display 1200 of an example 7, the field by which the inclination direction of the liquid crystal molecule in the circumference of contact hole 107a seen with the liquid crystal display 900 of an example 2 is not stabilized can be lost, and the liquid crystal display of good display grace with which the rough deposit of a display, an after-image, etc. are not checked by looking is obtained.

[0410] Here, as shown in drawing 66, it is desirable [the size of contact hole 117a] that it is the same as the size of opening 104a so that contact hole 117a may act on a liquid crystal molecule like [as possible] opening 104a. If contact hole 117a has the same configuration in the same size as opening 104a especially, the liquid crystal display excellent in especially the orientation stability of the periphery of contact hole 117a will be obtained. however, from a pixel pitch and the restrictions on structure, even when it is difficult to form contact hole 117a and opening 104a in the same size and the same configuration, it has symmetry-of-revolution nature for contact hole 117a and opening 104a -- as (the shape of a tetragonal lattice illustrated typically) -- the orientation of the surrounding liquid crystal layer of contact hole 117a can fully be stabilized by arranging

[0411] Of course, the composition illustrated by this example is possible also for applying to a transparency reflective two-ways type liquid crystal display, and can be suitably combined with a previous example.

[0412] Although some examples of the liquid crystal display by this invention were explained, the liquid crystal display of the operation gestalten 1-5 of this invention can be carried out similarly.

[0413]

[Effect of the Invention] Since according to this invention a two-layer structure electrode equipped with the upper conductive layer which has opening, a dielectric layer, and a lower layer conductive layer generates slanting electric field in the edge section of opening of the upper conductive layer and radial inclination orientation of the liquid crystal molecule of a perpendicular stacking-tendency liquid crystal layer is carried out by it, radial inclination orientation can be formed with stably sufficient repeatability. Therefore, according to this invention, the high liquid crystal display of display grace is offered.

[0414] If the upper conductive layer adopts especially the composition which has two or more openings, while covering the whole picture element field and acquiring stable radial inclination orientation, the liquid crystal display with which the fall of a speed of response was suppressed is offered.

[0415] Furthermore, if the composition which established the 2nd orientation regulation structure is adopted as the substrate which has a two-layer structure electrode (the 1st orientation regulation structure), and the substrate which

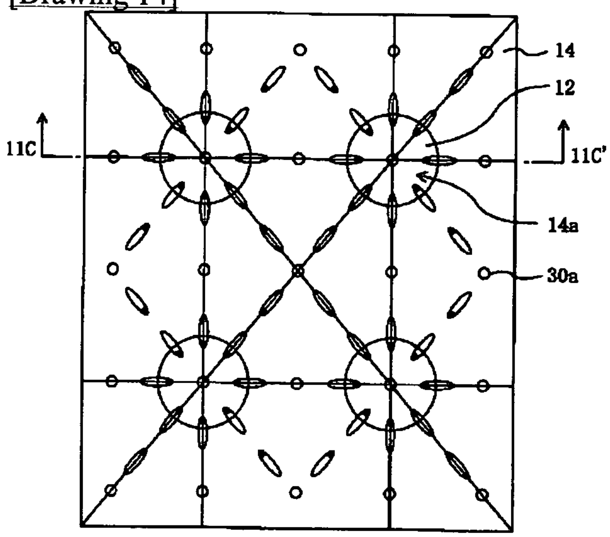
counters through a liquid crystal layer, the liquid crystal display which stabilized radial inclination orientation further will be offered. The effect which stabilizes orientation is acquired also by adopting the composition which has heights in opening of the upper conductive layer of a two-layer structure electrode.

[0416] Moreover, in the composition which has a crevice or a hole in the dielectric layer corresponding to opening of the upper conductive layer, adoption of the composition which makes the upper conductive layer a reflector and makes a lower layer conductive layer a transparent electrode offers the transparency reflective two-ways type liquid crystal display with which the display property of the transparent mode and the display property in reflective mode were optimized, respectively.

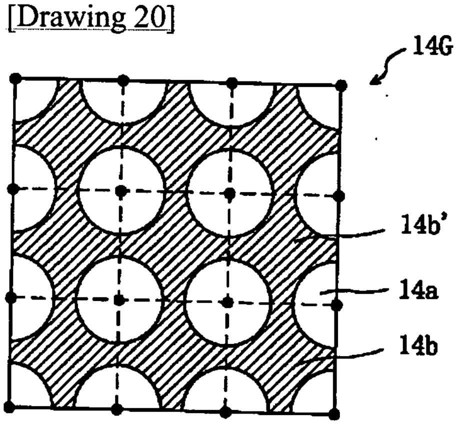
[Translation done.]

DRAWINGS

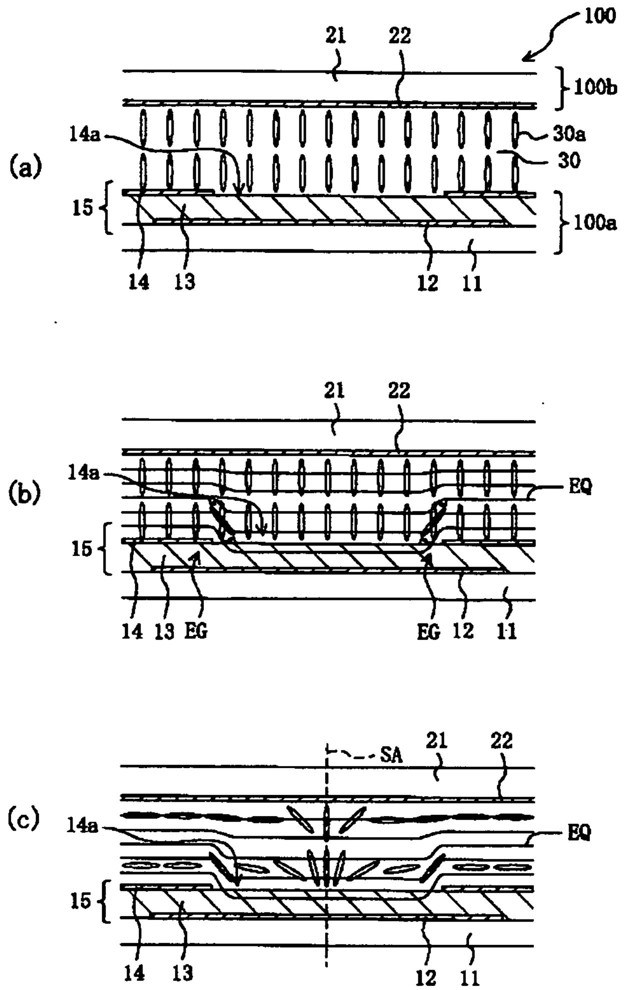
[Drawing 14]



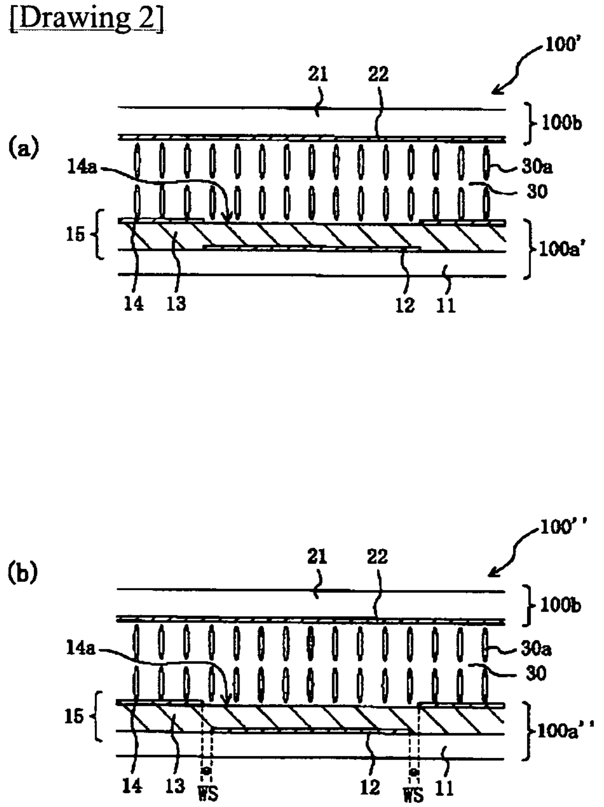
[Drawing 20]



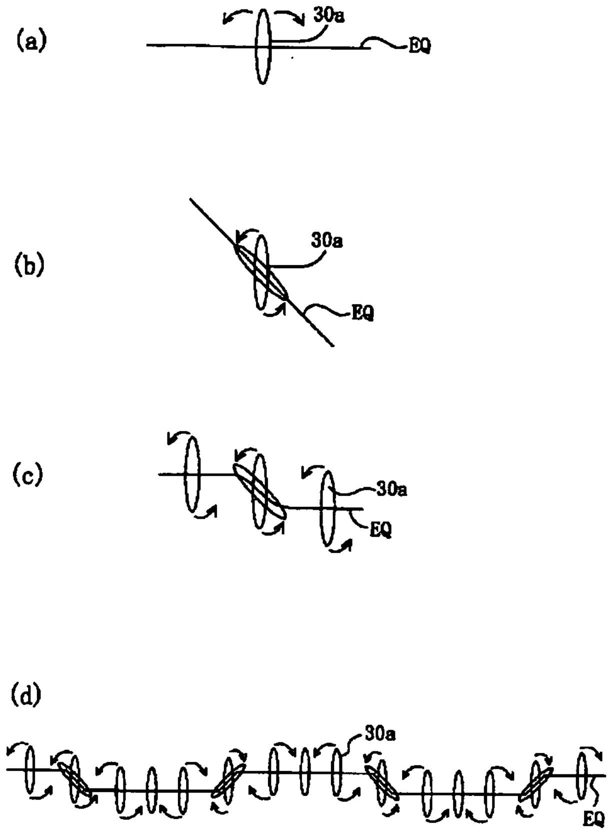
[Drawing 1]



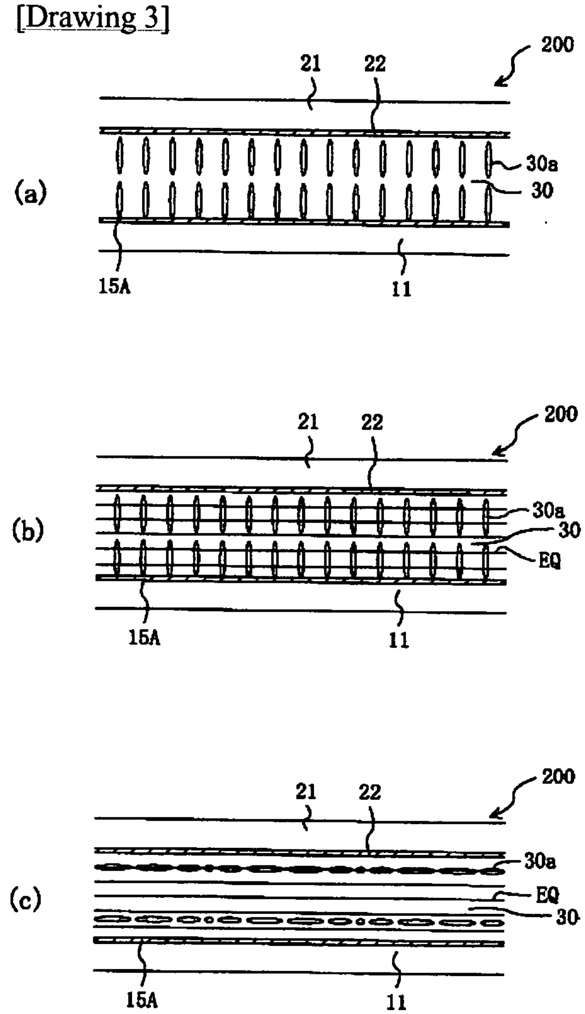
[Drawing 2]



[Drawing 5]

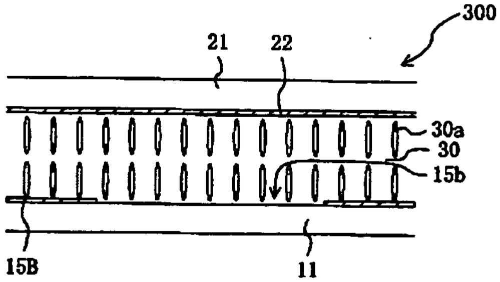


[Drawing 3]

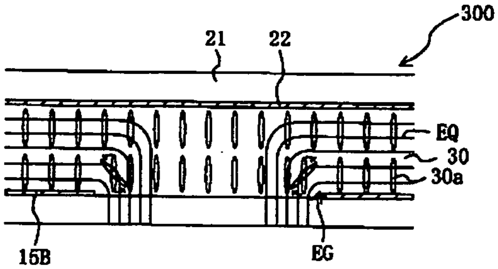


[Drawing 4]

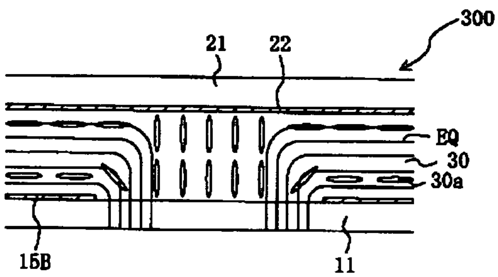
(a)



(b)

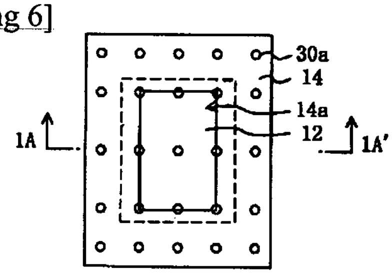


(c)

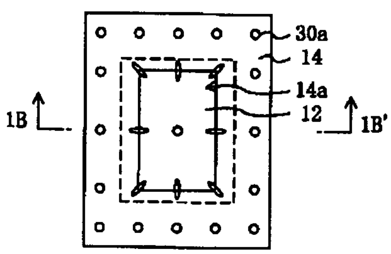


[Drawing 6]

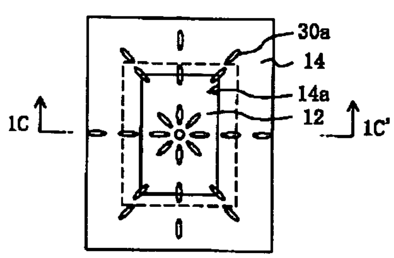
(a)



(b)

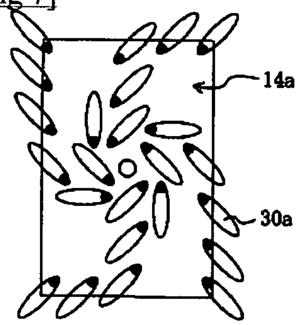


(c)

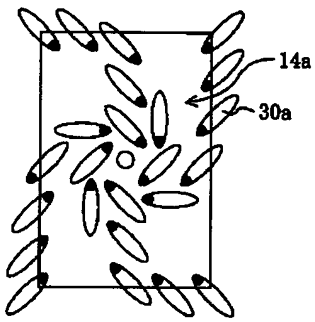


[Drawing 7]

(a)

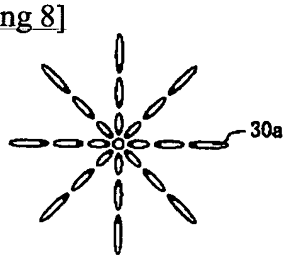


(b)

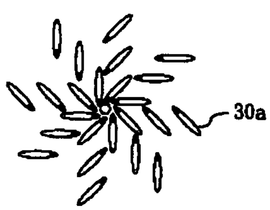


[Drawing 8]

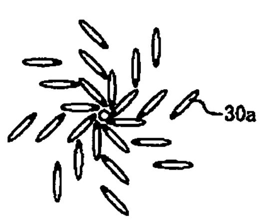
(a)



(b)

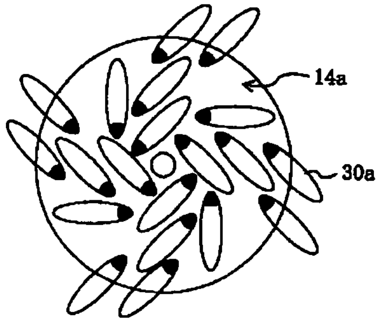


(c)

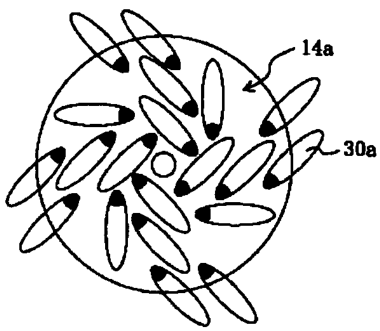


[Drawing 10]

(a)

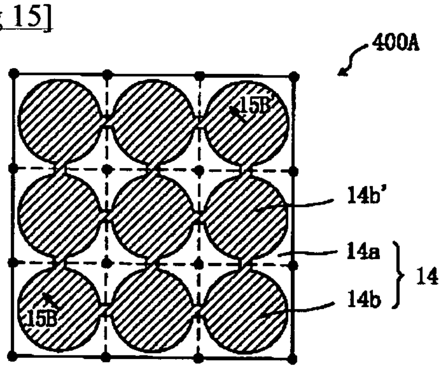


(b)

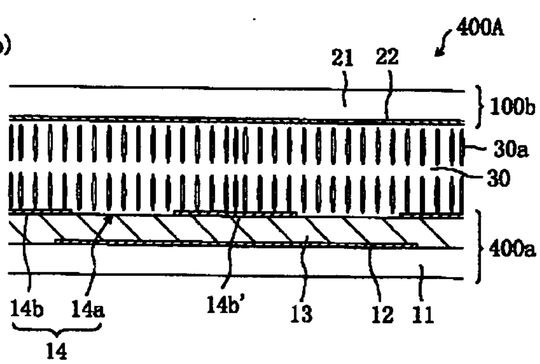


[Drawing 15]

(a)

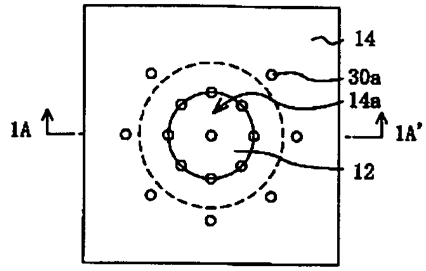


(b)

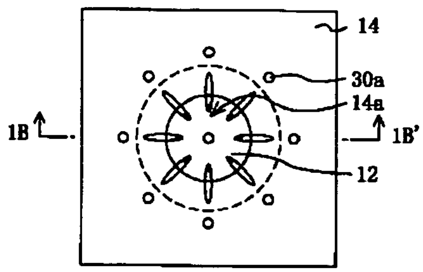


[Drawing 9]

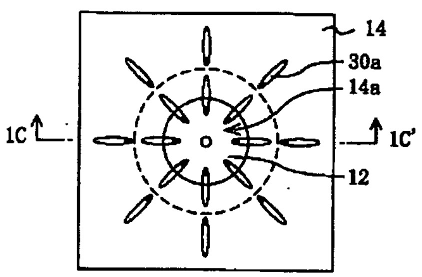
(a)



(b)

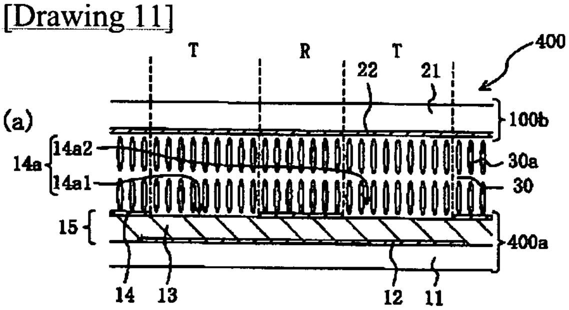


(c)

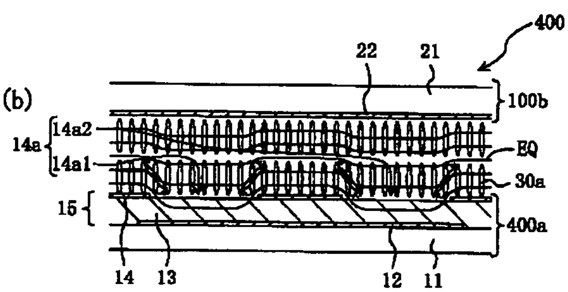


[Drawing 11]

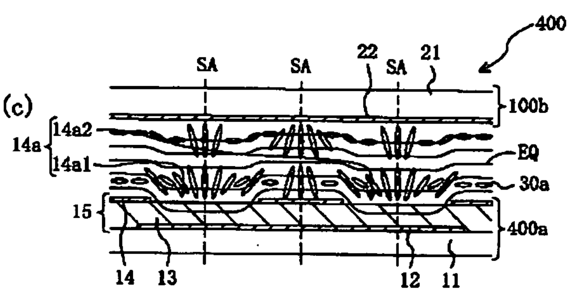
(a)



(b)

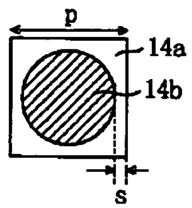


(c)

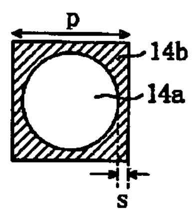


[Drawing 22]

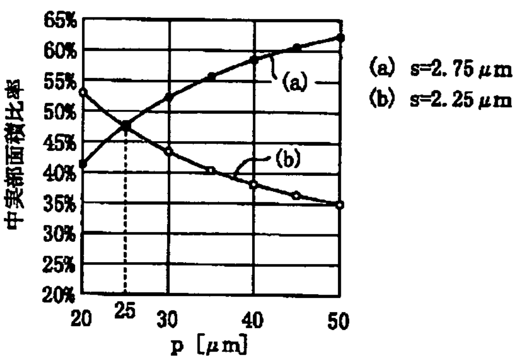
(a)



(b)

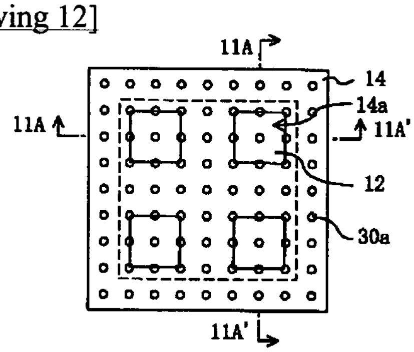


(c)

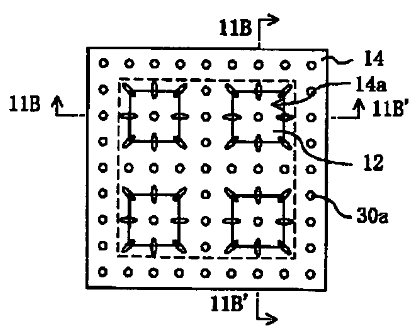


[Drawing 12]

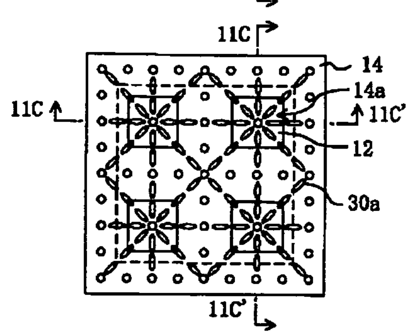
(a)



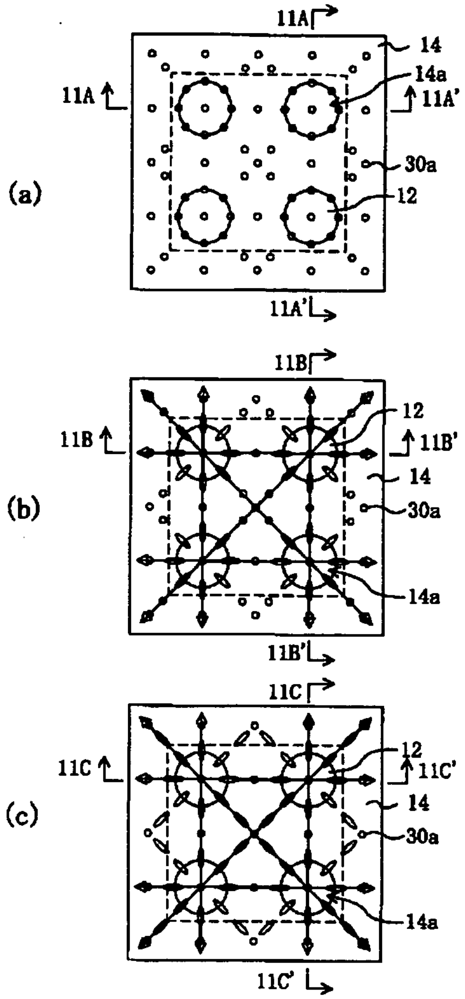
(b)



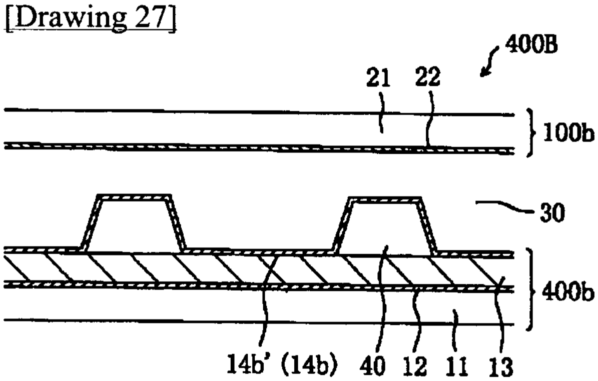
(c)



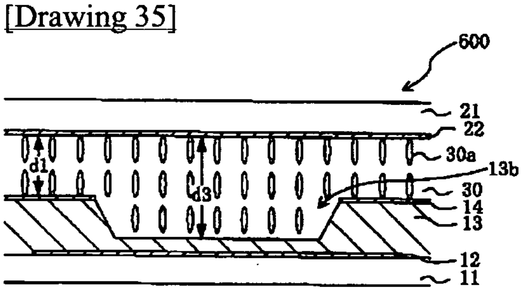
[Drawing 13]



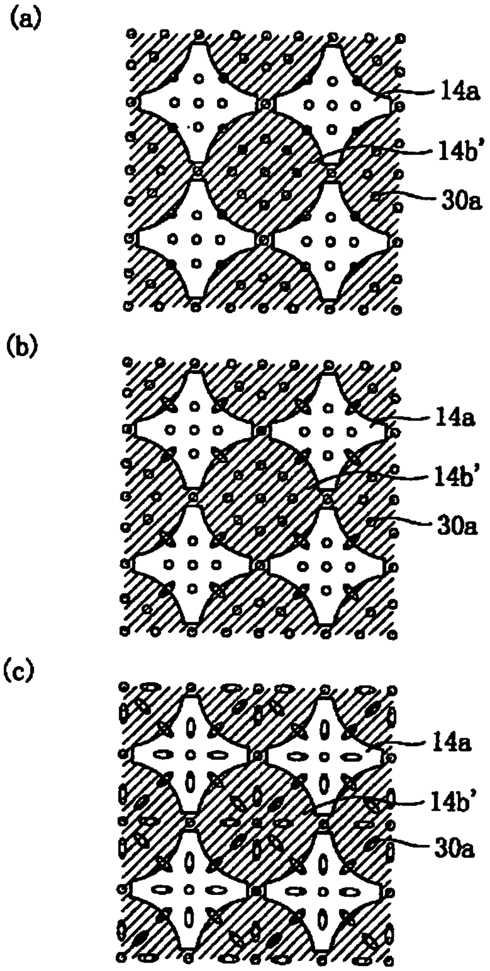
[Drawing 27]



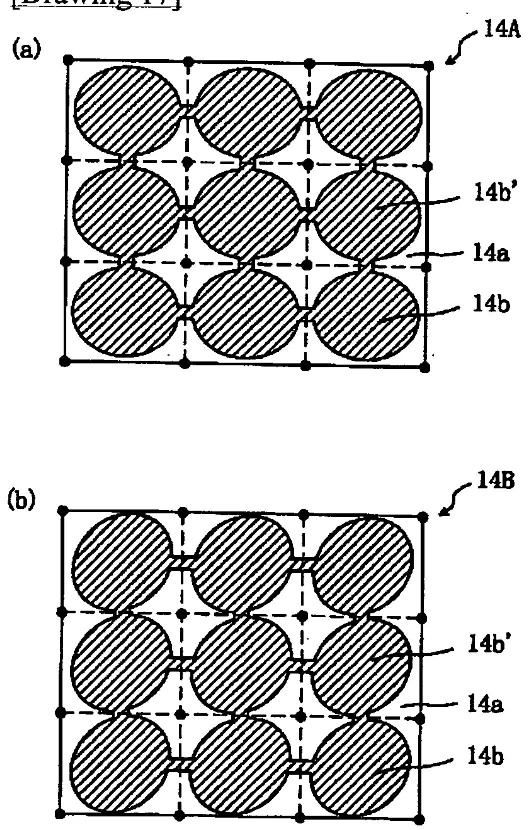
[Drawing 35]



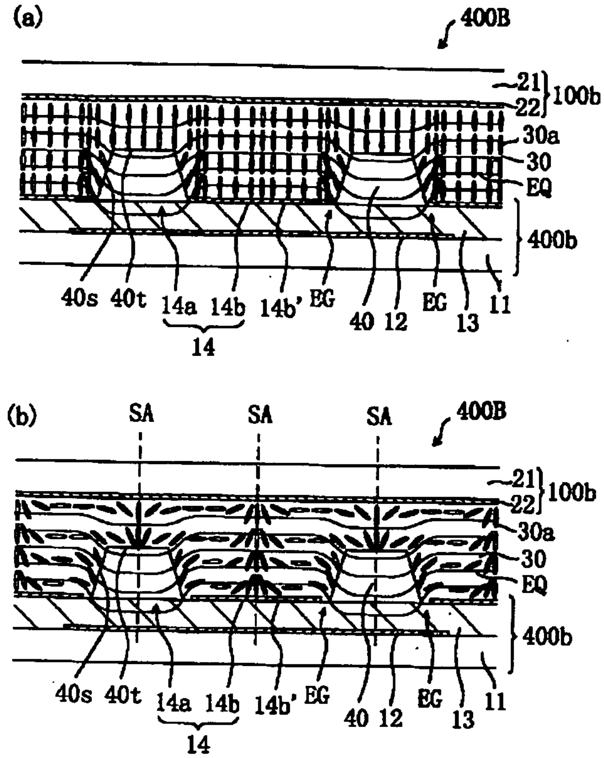
[Drawing 16]



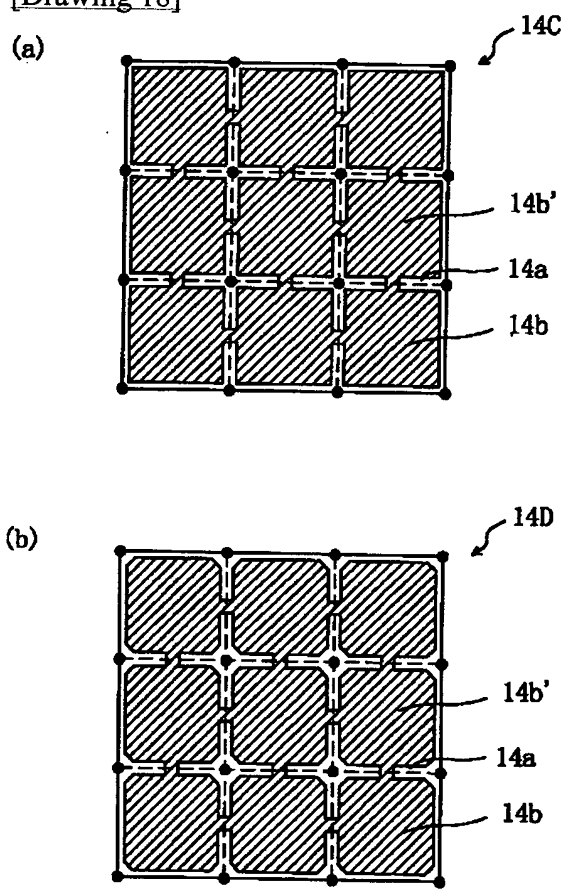
[Drawing 17]



[Drawing 25]

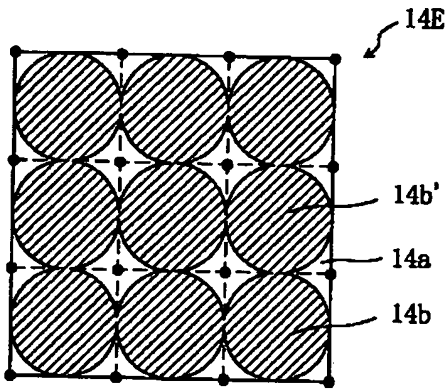


[Drawing 18]

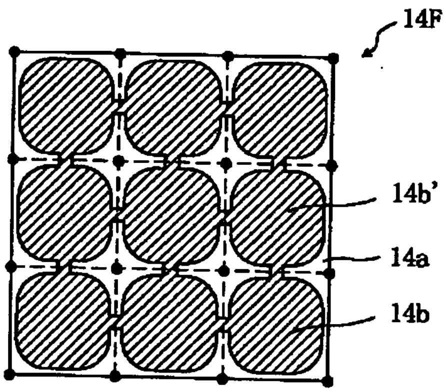


[Drawing 19]

(a)

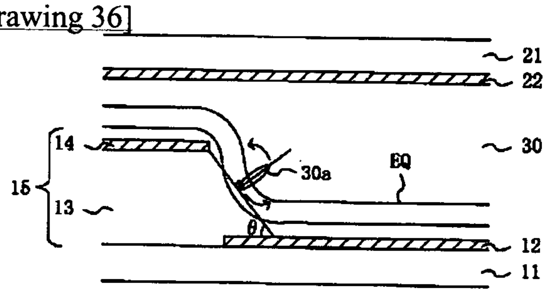


(b)

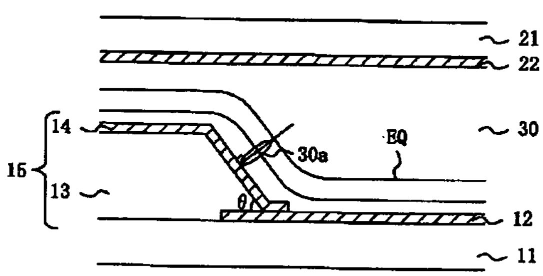


[Drawing 36]

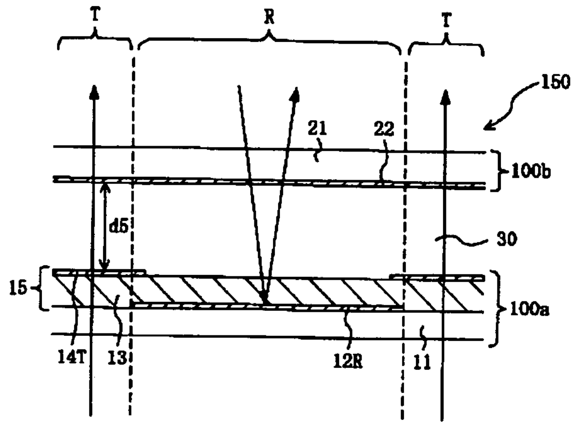
(a)



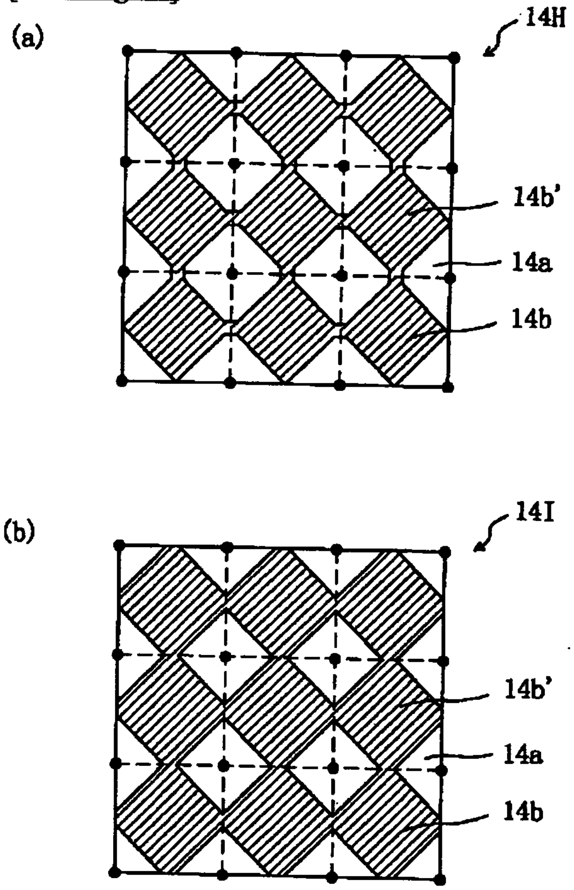
(b)



[Drawing 38 A]

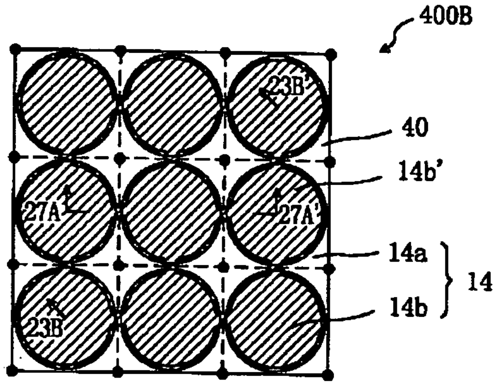


[Drawing 21]

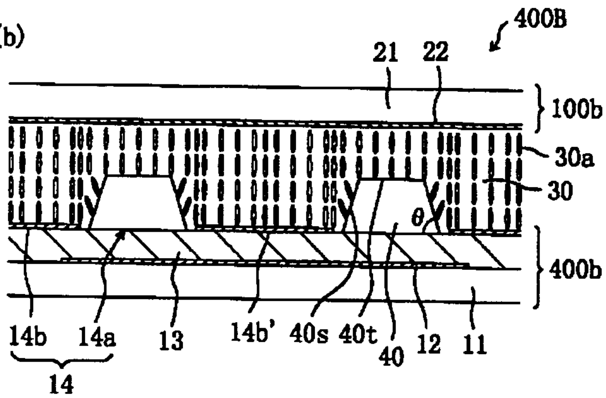


[Drawing 23]

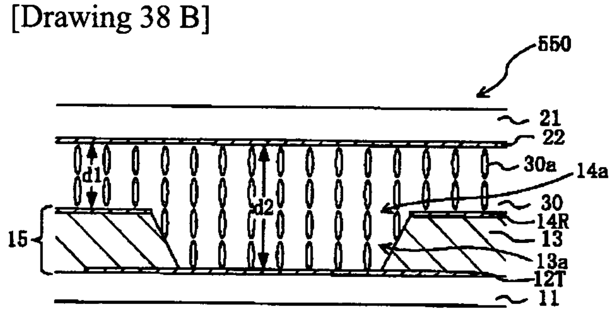
(a)



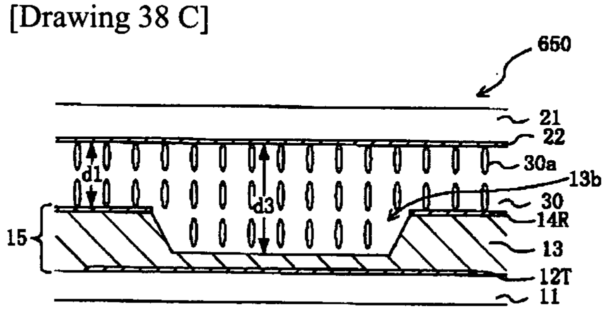
(b)



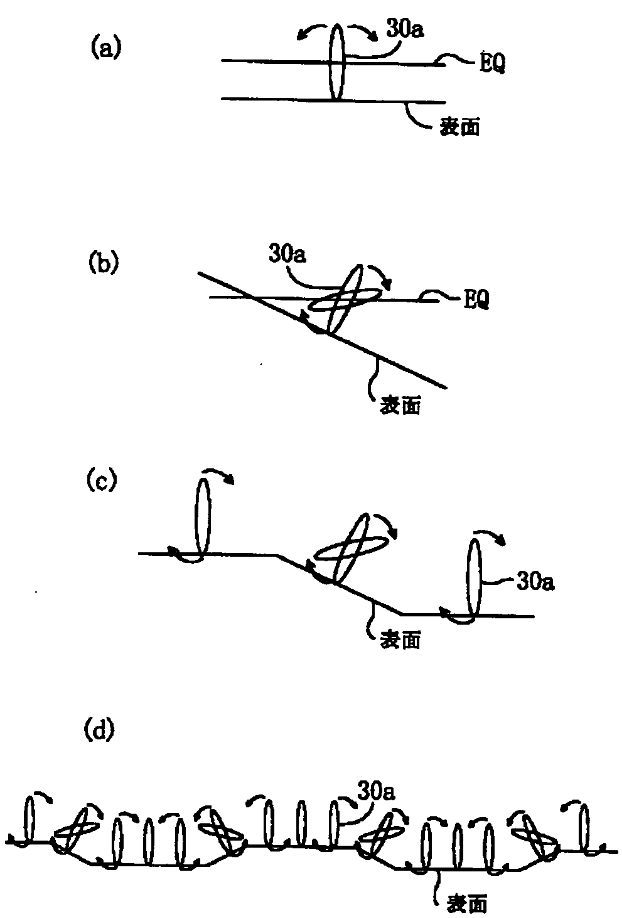
[Drawing 38 B]



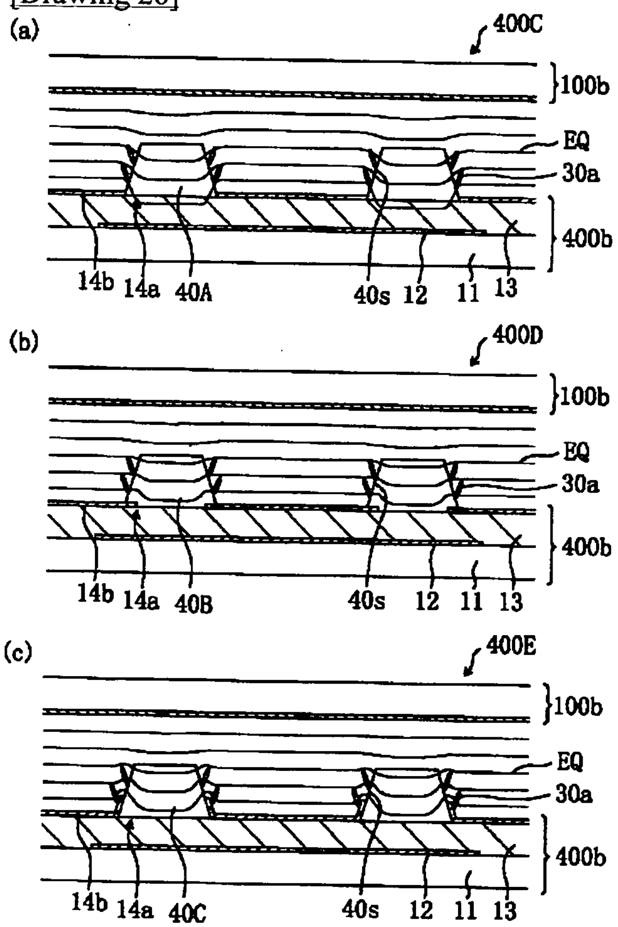
[Drawing 38 C]



[Drawing 24]

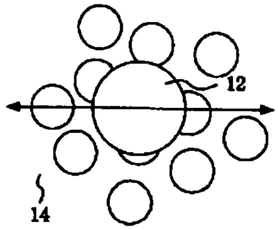


[Drawing 26]

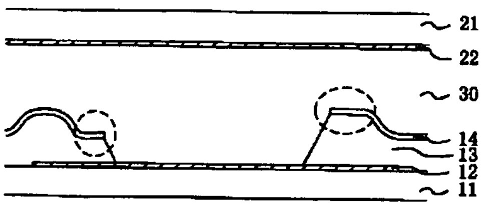


[Drawing 39]

(a)

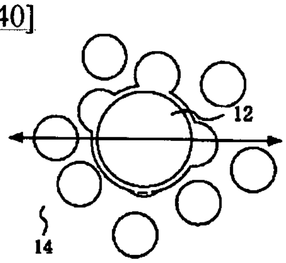


(b)

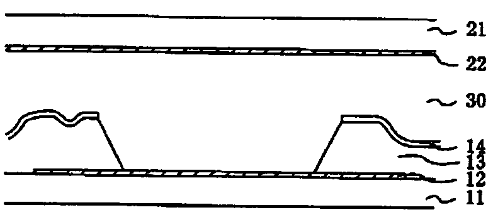


[Drawing 40]

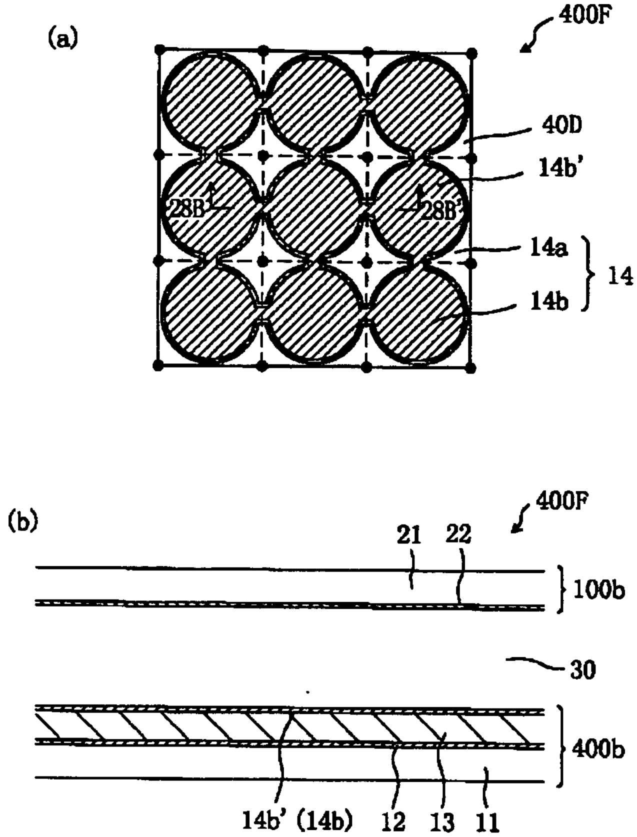
(a)



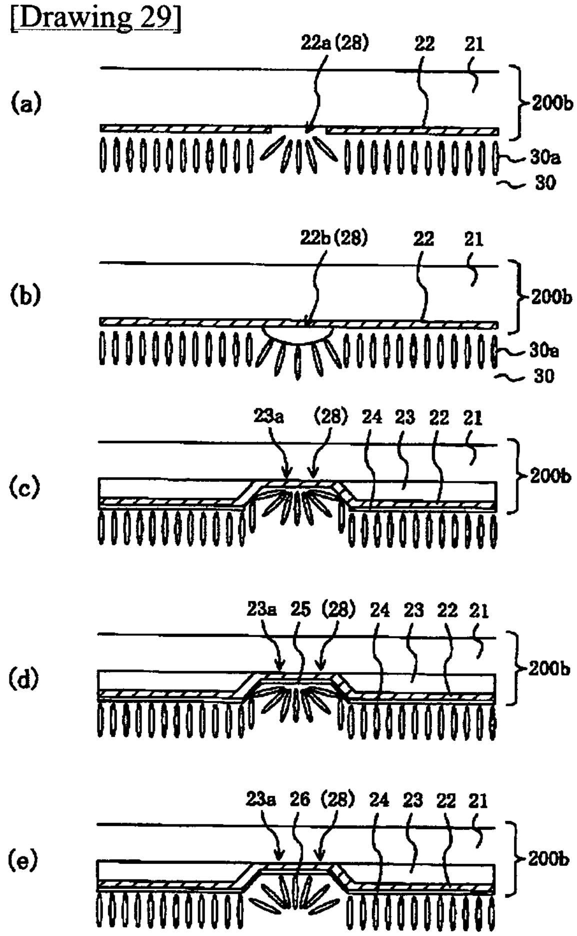
(b)



[Drawing 28]

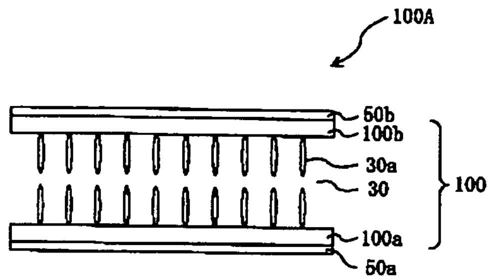


[Drawing 29]

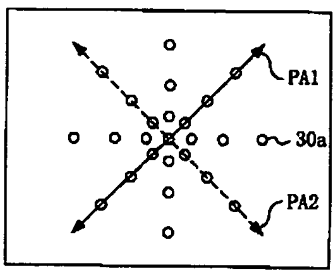


[Drawing 41]

(a)

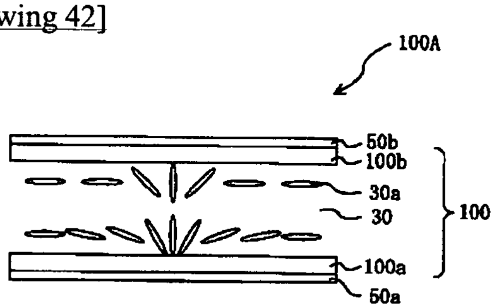


(b)

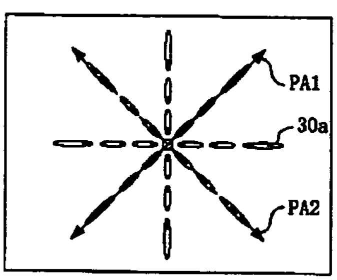


[Drawing 42]

(a)

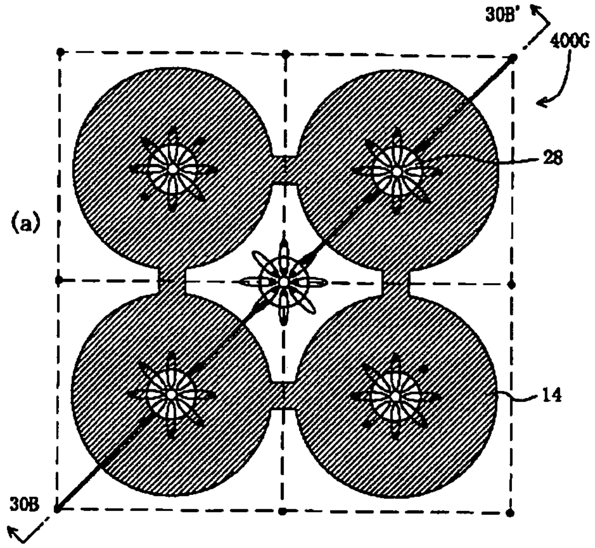


(b)

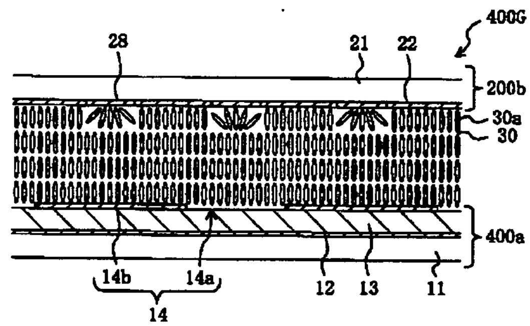


[Drawing 30]

(a)

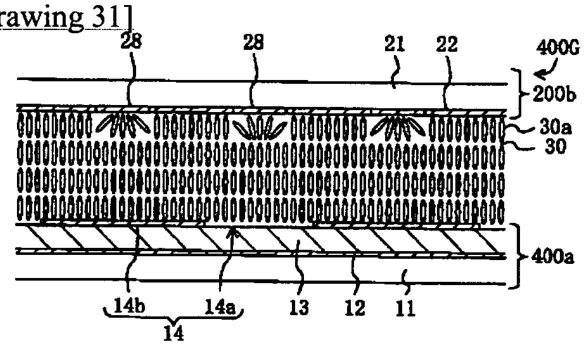


(b)

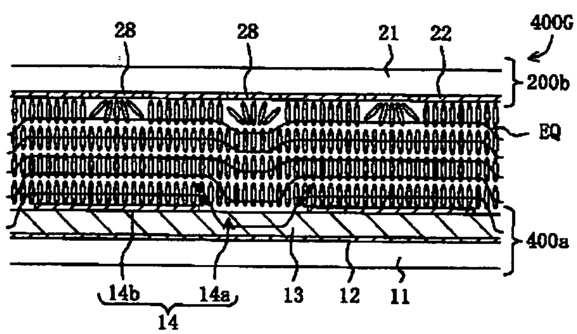


[Drawing 31]

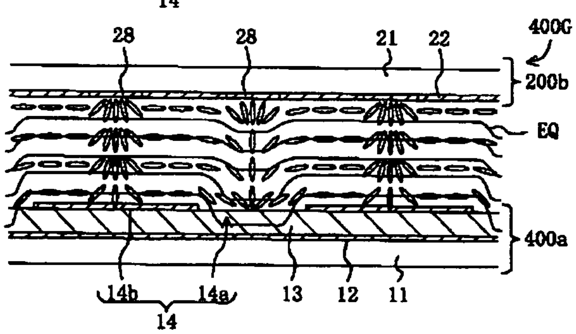
(a)



(b)

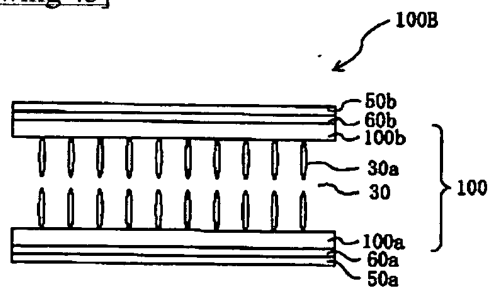


(c)

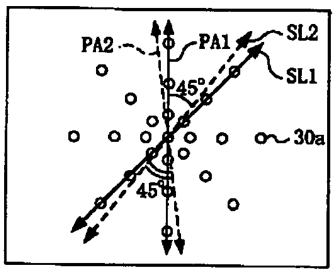


[Drawing 43]

(a)

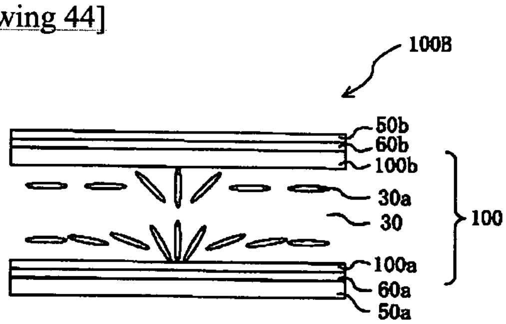


(b)

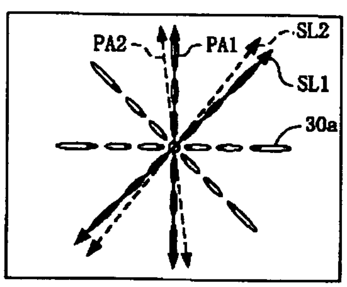


[Drawing 44]

(a)

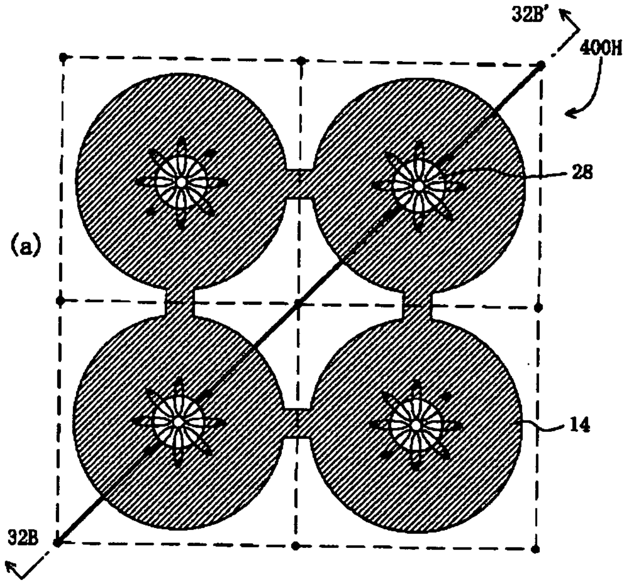


(b)

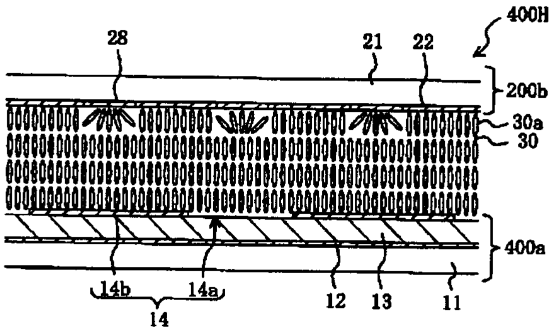


[Drawing 32]

(a)

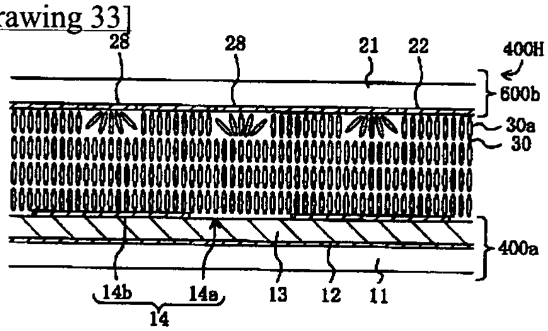


(b)

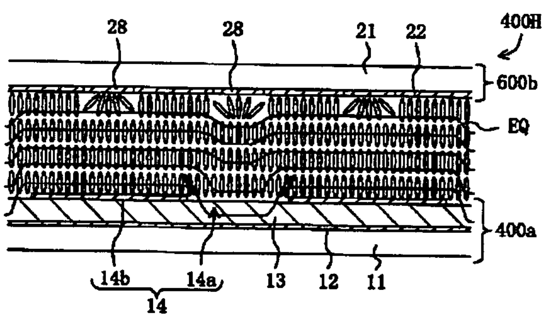


[Drawing 33]

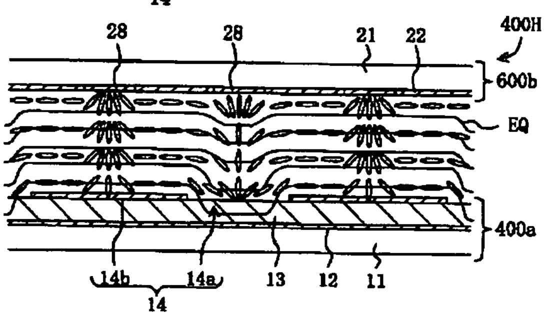
(a)



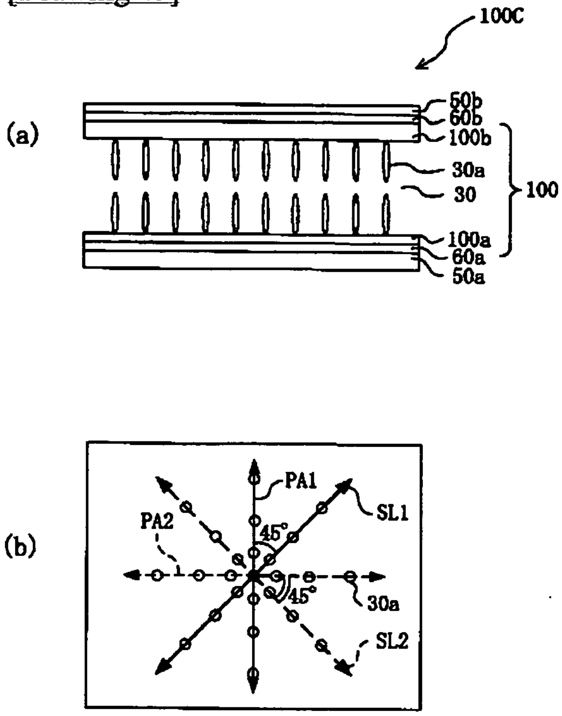
(b)



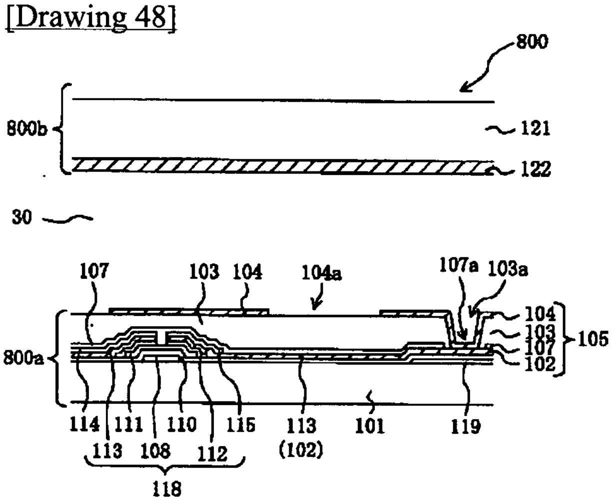
(c)



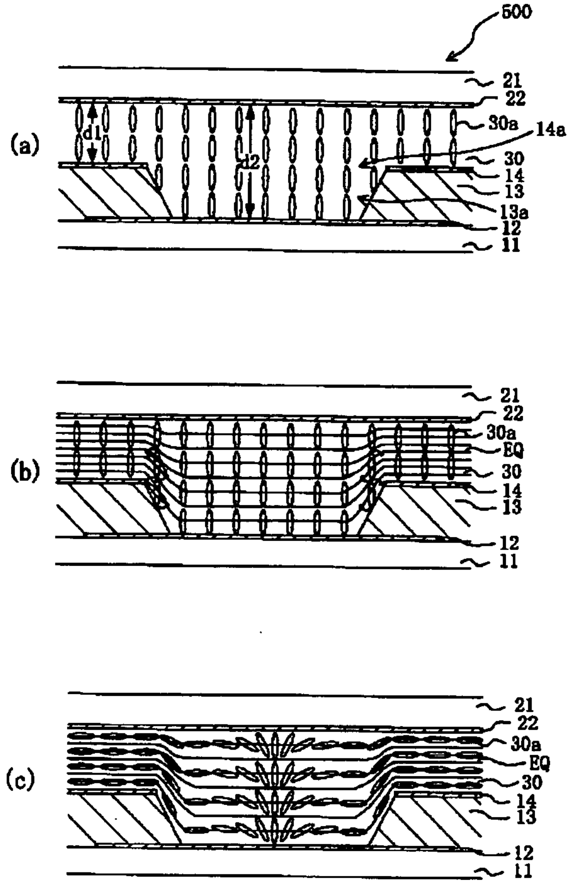
[Drawing 45]



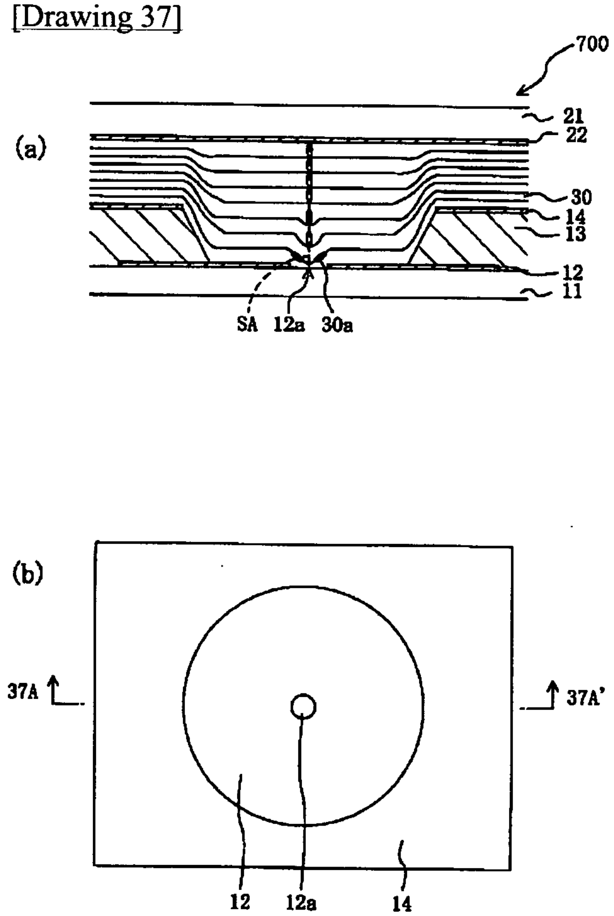
[Drawing 48]



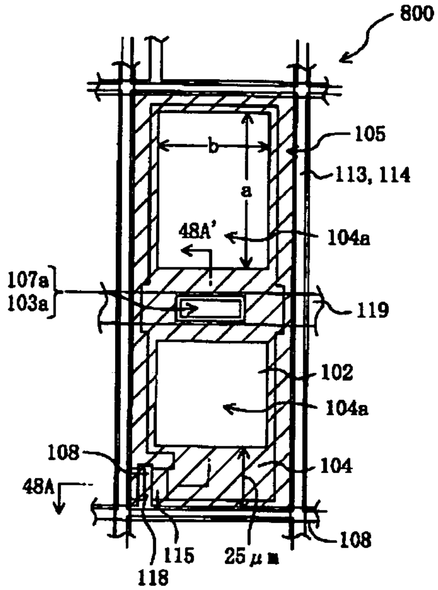
[Drawing 34]



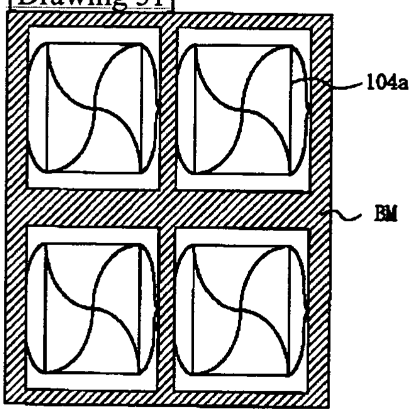
[Drawing 37]



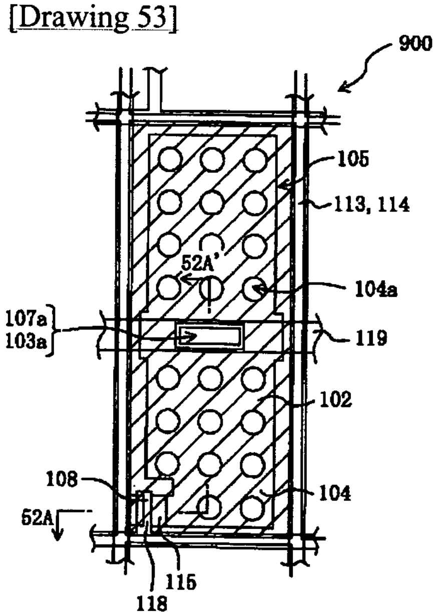
[Drawing 49]



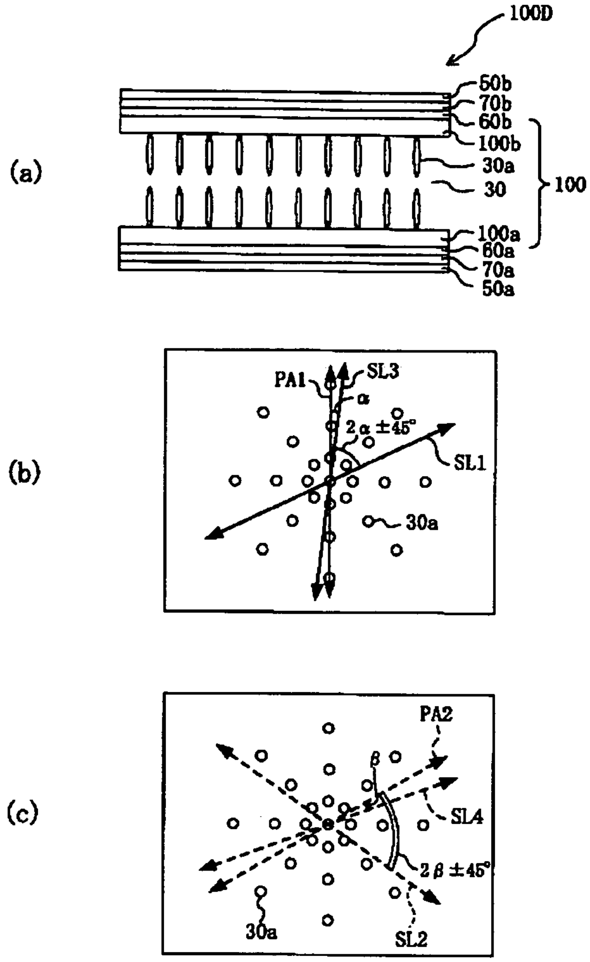
[Drawing 51]



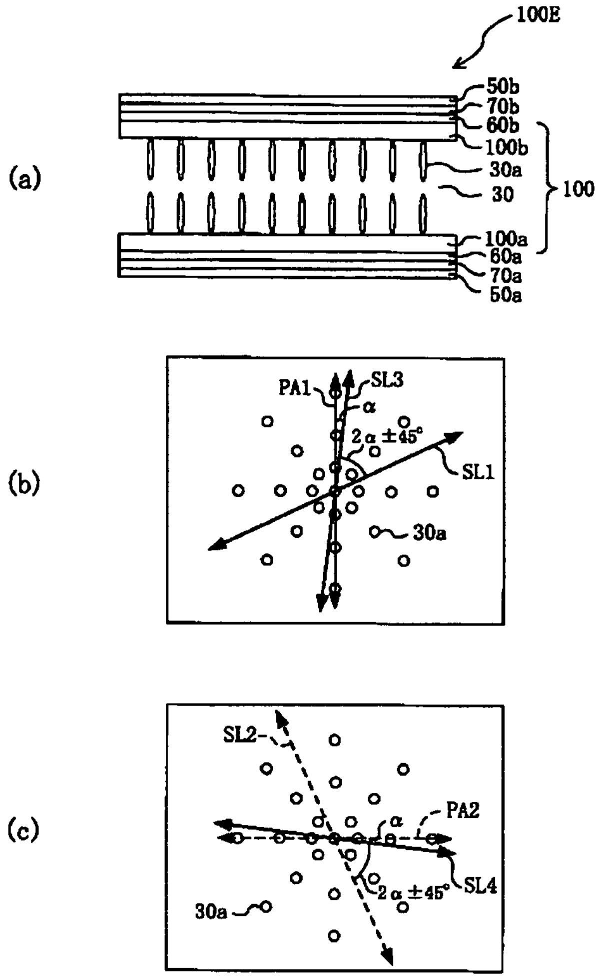
[Drawing 53]



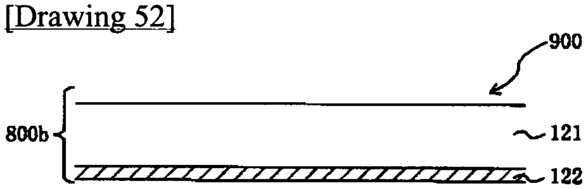
[Drawing 46]

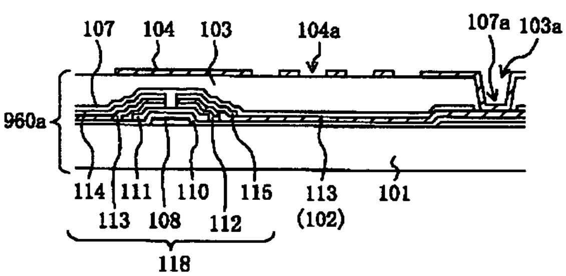

100D
(a)
50b
70b
60b
100b
30a
30
100
100a
60a
70a
50a
(b)
PA1
SL3
α
2α ±45°
SL1
30a
(c)
PA2
β
SL4
2β ±45°
30a
SL2

[Drawing 47]

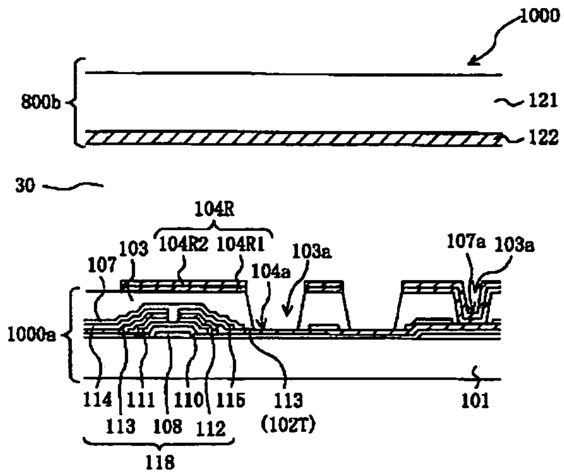


[Drawing 52]

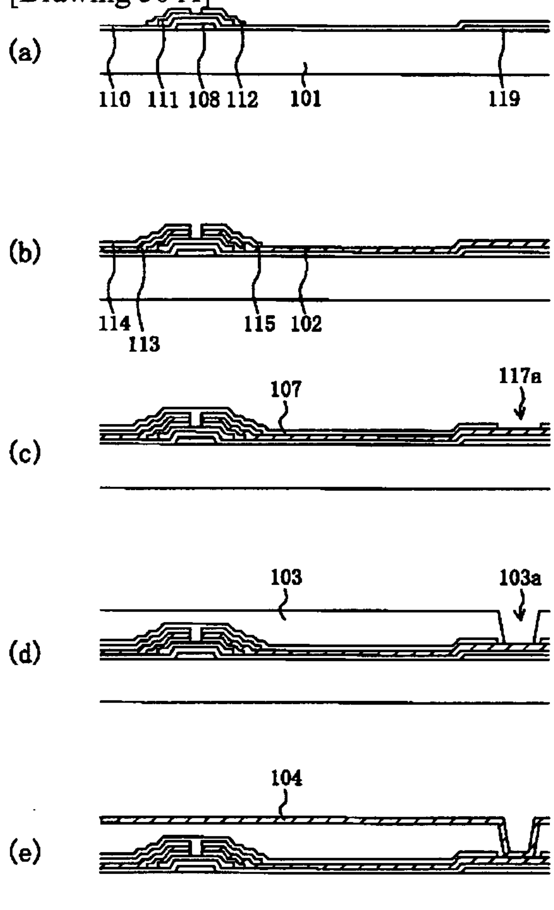




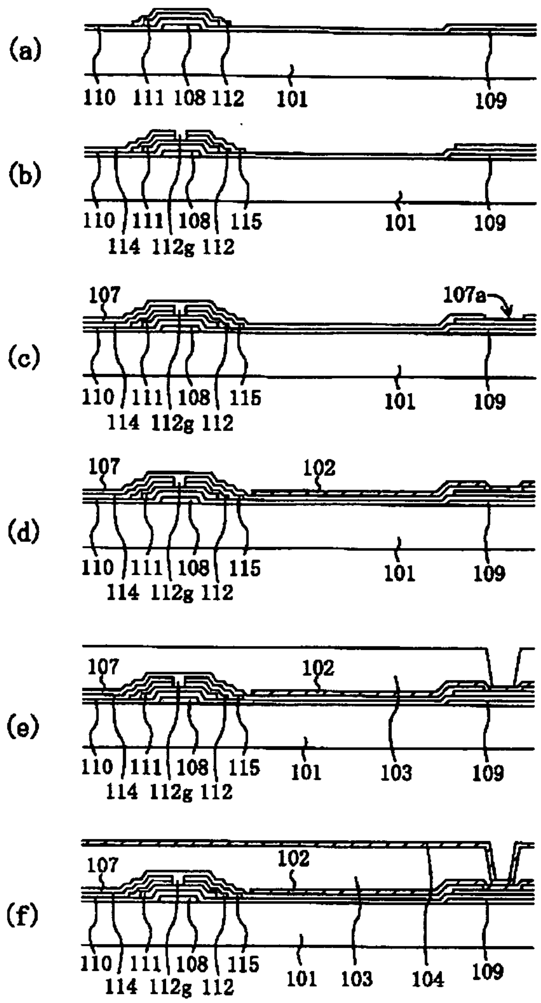
[Drawing 54]



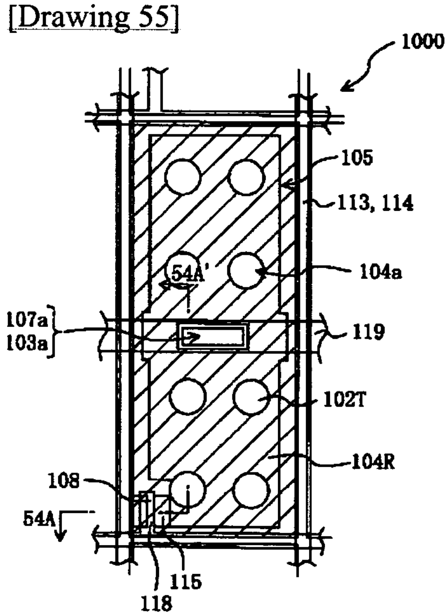
[Drawing 50 A]



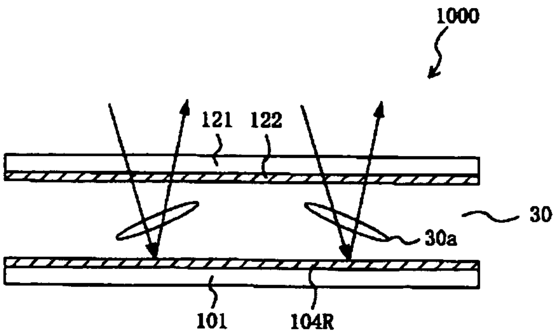
[Drawing 50 B]



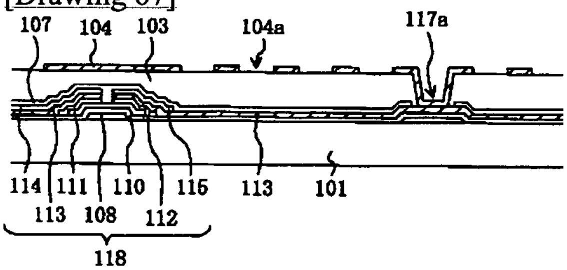
[Drawing 55]



[Drawing 57]

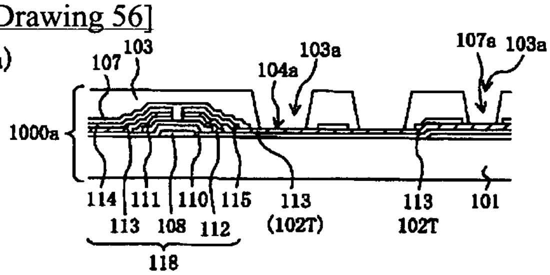


[Drawing 67]

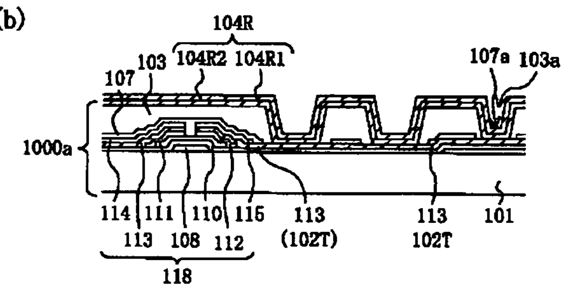


[Drawing 56]

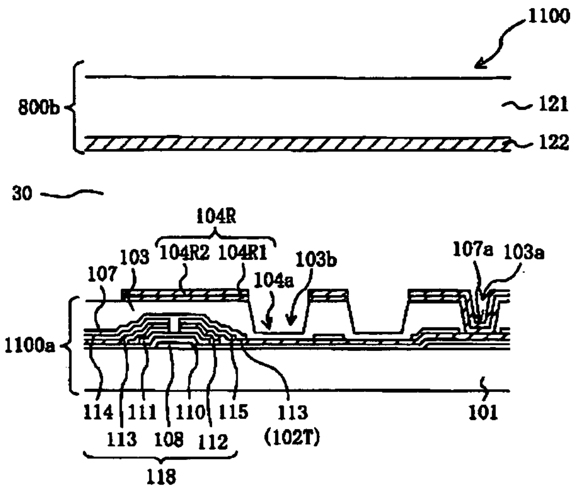
(a)



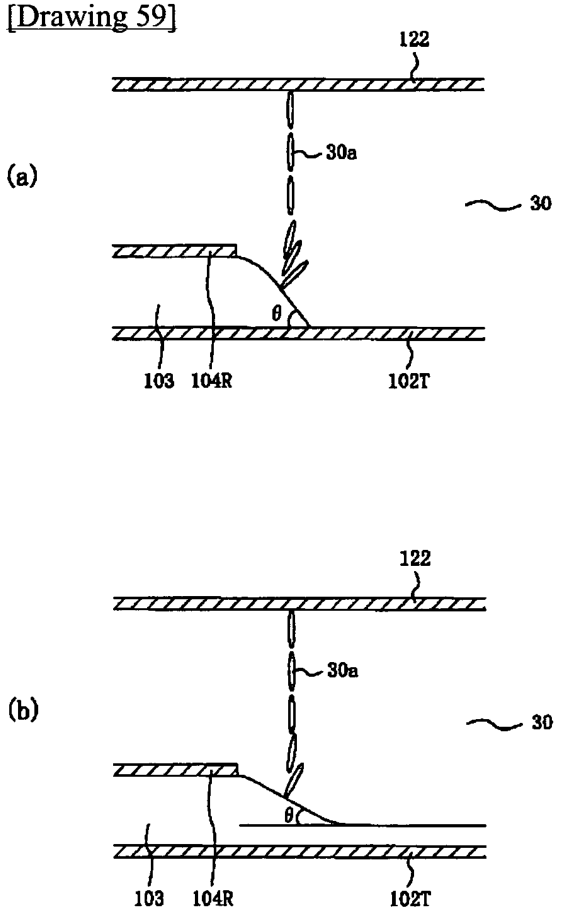
(b)



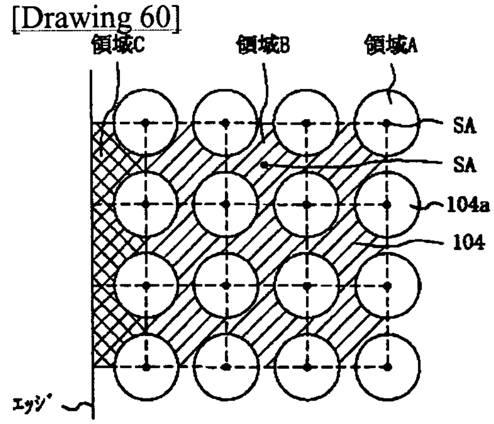
[Drawing 58]



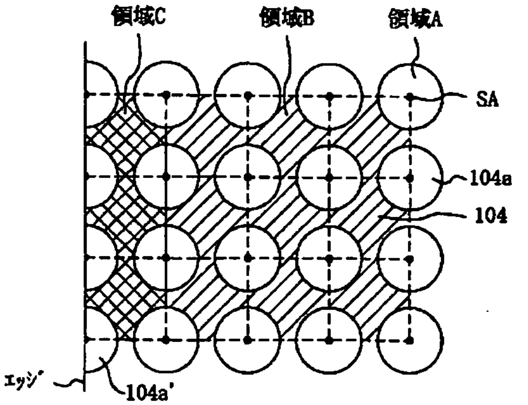
[Drawing 59]



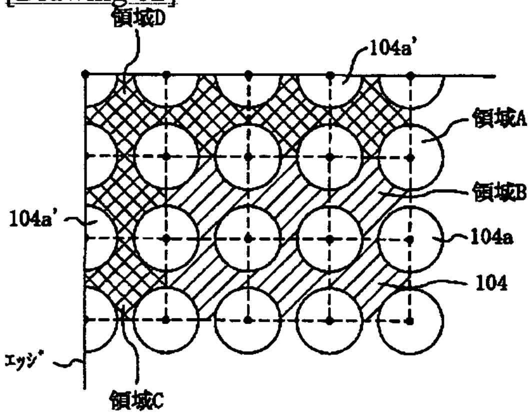
[Drawing 60]



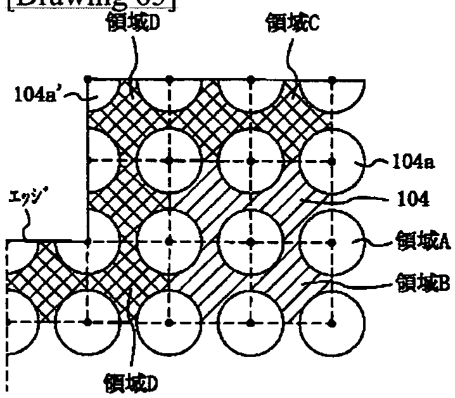
[Drawing 61]



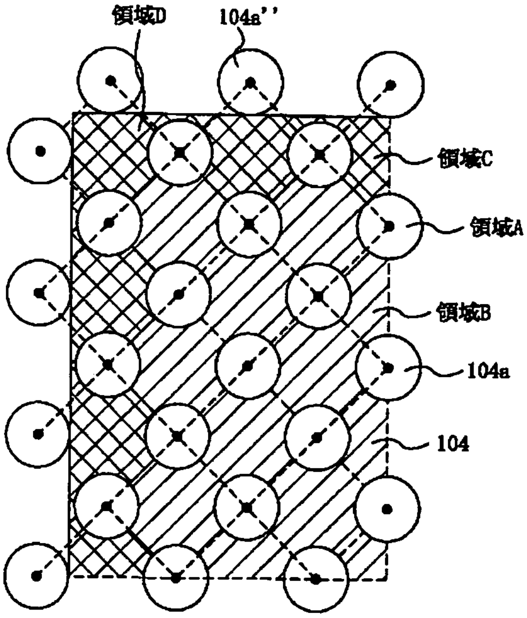
[Drawing 62]



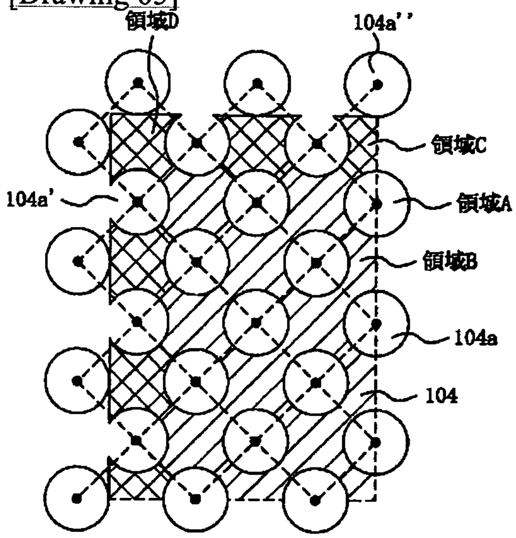
[Drawing 63]



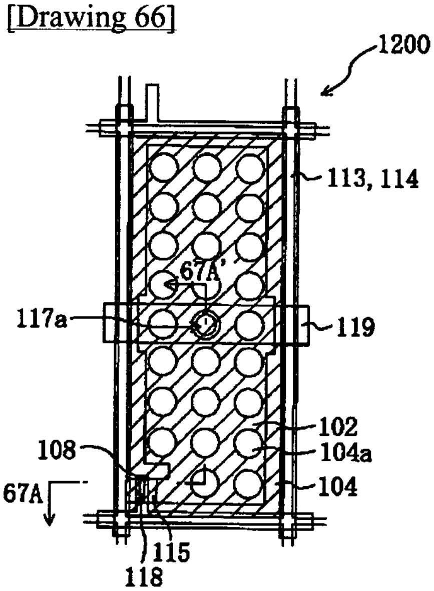
[Drawing 64]



[Drawing 65]



[Drawing 66]



[Translation done.]